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Preparatory to CICAR
Organized jointly by FAO and Unesco

PAPERS ON FISHERY RESOURCES

Coloquio sobre Investigaciones y Recursos del Mar Caribe y Regiones Adyacentes

Preparatorio a las ICCRA
Auspiciado conjuntamente por la FAO y la Unesco

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Symposium on Investigations and Resources of the Caribbean Sea and Adjacent Regions

Preparatory to the
Co-operative Investigations of the Caribbean
and Adjacent Regions (CICAR)
Organized jointly by FAO and Unesco

Willemstad, Curaçao, Netherlands Antilles
18-26 November 1968

PAPERS ON FISHERY RESOURCES

Edited by
Marine Biology and Environment Branch
Fishery Resources Division
FAO, Rome

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18-26 de noviembre de 1968

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Rome, September 1971 Roma, Septiembre 1971

EDITORIAL NOTE

This publication forms part of the Proceedings of the Symposium on Investigations and Resources of the Caribbean Sea and Adjacent Regions organized jointly by Unesco and FAO and co-sponsored by WMO, held in Willemstad, Curaçao, from 18 to 26 November 1968. The Symposium was preparatory to the Cooperative Investigations in the Caribbean and Adjacent Regions (CICAR), started in 1970 under the aegis of the Intergovernmental Oceanographic Commission (IOC). The present volume, issued by FAO in its Fisheries Reports series, contains the full texts in their original language of the papers contributed to the Fishery Resources Section of the Symposium.

The integral texts of the contributions to the Symposium sections on Physical and Chemical Oceanography, Marine Geology and Geophysics and Marine Biology are published by Unesco.

NOTA EDITORIAL

Esta publicación forma parte de las Actas del Coloquio sobre Investigaciones y Recursos del Mar Caribe y Regiones Adyacentes, organizado conjuntamente por la FAO y la Unesco y copatrocinado por la OMM, que tuvo lugar en Willemstad, Curaçao, del 18 al 26 de noviembre de 1968. El Coloquio fue preparatorio a las Investigaciones Cooperativas del Mar Caribe y Regiones Adyacentes (ICCRA) que comenzó en 1970 bajo la égida de la Comisión Oceanográfica Intergubernamental (COI). El presente volumen, editado por la FAO en su serie de Informes de Pesca, contiene el texto íntegro en su lengua original de las comunicaciones presentadas a la Sección de Recursos Pesqueros.

El texto completo en su lengua original de las comunicaciones presentadas a las secciones de Oceanografía Física y Química, Geología Marina y Geofísica, y Biología Marina del Coloquio es publicado por la Unesco.

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PREFACE

In November 1968 a Symposium on Investigations and Resources of the Caribbean Sea and Adjacent Regions was held at Willemstad, Curaçao, Netherlands Antilles, under the joint sponsorship of the United Nations Educational, Scientific and Cultural Organization and the Food and Agriculture Organization of the United Nations; in addition, the World Meteorological Organization sponsored certain lectures. Local arrangements and services were provided by the Government of the Netherlands Antilles.

At its fifth session in 1967, the Intergovernmental Oceanographic Commission had adopted a proposal, presented through the initiative of the Netherlands delegation, for Co-operative Investigations of the Caribbean and Adjacent Regions (CICAR) to be conducted from 1970 onwards. The purpose of the Symposium, which was designed to facilitate the planning of the scientific programme for CICAR, was defined as follows: To review knowledge and to identify existing gaps in the field of scientific investigations and of resources research in order to improve scientific co-operation and rational use of marine resources in the Caribbean, the Gulf of Mexico and adjacent regions.

The present volume, issued by FAO, forms part of the Proceedings of the Symposium. It contains the papers on fishery resources submitted to FAO for publication in this volume. An introductory volume containing the report of the Symposium and abstracts of all the papers has already been issued (FAO Fisheries Reports, No. 71.1, Rome, December 1969, English version, and September 1970, Spanish version).

The texts of the contributions to the Symposium sections on Physical and Chemical Oceanography, Marine Geology and Geophysics and Marine Biology are published by Unesco.

The views expressed in the papers are those of the authors, and do not necessarily reflect policies of the sponsoring agencies.

PREFACIO

En noviembre de 1968 se celebró en Willemstad, Curaçao, Antillas Holandesas, un Coloquio sobre Investigaciones y Recursos del Mar Caribe y Regiones Adyacentes, patrocinado conjuntamente por la Organización de las Naciones Unidas para la Educacción, la Ciencia y la Cultura y la Organización de las Naciones Unidas para la Agricultura y la Alimentación; la Organización Meteorológica Mundial patrocinó, además, diversas conferencias. El Gobierno de las Antillas Holandesas proporcionó los locales y servicios necesarios.

La Comisión Oceanográfica Intergubernamental, en su quinta reunión en 1967, había aprobado una propuesta, presentada por la delegación de los Países Bajos, de Investigaciones Cooperativas del Mar Caribe y Regiones Adyacentes (ICCRA) que debería llevarse a cabo a partir de 1970. El Coloquio estaba destinado a facilitar el planeamiento del programa científico de las ICCRA: su objectivo fue definido en los siguientes términos: examinar los conocimientos que se poseen en la esfera de las investigaciones científicas y las investigaciones sobre los recursos, a fin de descubrir las lagunas existentes con objeto de mejorar la cooperación científica y la utilización racional de los recursos marinos en el Mar Caribe, el Golfo de México y las zonas adyacentes.

El presente volumen, publicado por la FAO, forma parte de las Actas del Coloquio. Contiene ensayos sobre recursos pesqueros presentados a la FAO para su publicación en este volumen. Un volumen de introducción que contiene el informe sobre el Coloquio y resúmenes de todas las comunicaciones presentadas, ha sido ya publicado (FAO Informes de Pesca, nº 71.1, Roma, diciembre de 1969, versión inglesa, y septiembre de 1970, versión española).

Los textos relativos a las secciones de Oceanografía Física y Química, Geología Marina y Geofísica, y Biología Marina del Coloquio son publicados por la Unesco.

Las ideas expresadas en las comunicaciones son las de sus autores, y no reflejan necesariamente la política de las organizaciones patrocinadoras.

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TAXONOMIC STATUS OF WESTERN ATLANTIC CLUPEOID FISHES[1]

by

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1 INTRODUCTION

The clupeoid fishes, order Clupeiformes, are presently restricted to four families: Clupeidae, Engraulidae, Chirocentridae and Denticipitidae. The herrings or clupeids (Clupeidae) and the anchovies (Engraulidae) each contain more than 100 valid species and have several hundred nominal species, most of which are synonyms or invalid; the Chirocentridae have two species (Luther, 1968) and the Denticipitidae, one (Greenwood et al., 1966).

The clupeoid fishes are a very important natural food resource to the world. For example, in 1966 clupeoids contributed about 33% of the world's catch of aquatic animals and plants by weight (excluding whales) and about 41% of the total catch of marine fishes. Clupeoid fishes, caught by current fishing techniques, can serve as one of the greatest sources of protein from the sea, until advanced technological methods are developed for obtaining other ocean protein.

Four species of clupeoids have been intensively fished in temperate waters: California sardine, Atlantic menhaden, Peruvian anchoveta, and North Atlantic herring. The first two of these are now greatly reduced in numbers, distribution, and production. Probably many tropical and subtropical clupeoids will be heavily exploited within the next decade. To sustain these valuable resources and to prevent stock reduction of other clupeoid fishes, management of the fisheries is mandatory. Effective management of fisheries for the various species of Western Atlantic clupeoid fishes first requires adequate knowledge of their biology and environmental relationships. In the Western Atlantic area, the biology of only a few groups of temperate water clupeoids (North Atlantic herring, menhaden, and shad) has been investigated. Very little research has been directed toward the biology of tropical and subtropical groups of clupeoids, and scientific information on these is extremely fragmentary and inadequate.

Species compositions of many groups of Western Atlantic clupeoids are uncertain. Many of the species are difficult or impossible to identify, even for experts. In more instances, juvenile stages are not identifiable by the characters that have been determined for adults, and larval stages for few

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[1] Contribution No.107, Bureau of Commercial Fisheries Tropical Atlantic Biological Laboratory, Miami, Florida 33149

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species can be identified. Two major reasons account for the current uncertainties: 1) Adequate samples of complete size series of the various forms of clupeoids from throughout their ranges have not been collected and assembled for study. 2) Sufficient research has not been applied to the taxonomy of these fishes. The Tropical Atlantic Biological Laboratory is working on these problems.

Taxonomy of Western Atlantic Engraulidae was last collectively treated in a revision that emphasized western North Atlantic species (Hildebrand, 1964). That report described 39 species. My preliminary analysis of taxonomic uncertainties suggests that between 34 and 44 species of anchovies may occur in the Western Atlantic.

The species of Clupeidae from the Western Atlantic area that I believe are either valid or must be provisionally recognized are listed below. Known ranges are given, and known and suspected taxonomic problems are briefly noted. For the 20 currently recognized genera, 44 species are listed. Considering the taxonomic uncertainties that are apparent or anticipated, the actual number of Western Atlantic species of clupeids is estimated to be between 32 and 56.

2 SUBFAMILY DUSSUMIERIINAE

Genus *Etrumeus* Bleeker, 1853. Roundherrings. One species.

Etrumeus teres (DeKay, 1842). Atlantic roundherring. Marine. Considered to be a single species in all oceans, with seven populations that are probably discrete (Whitehead, 1963); in the Western Atlantic from Nova Scotia to the Gulf of Mexico and at Trinidad. Referred to previously (Whitehead, 1965) as *E. sadina* (Mitchill, 1814). An oceanic species, obviously in need of further analysis.

Genus *Jenkinsia* Jordan and Evermann, 1896. Dwarfherrings. Currently described as two Western Atlantic species, each with two subspecies (Whitehead, 1963). Research in progress suggests that from four to as many as seven species exist and that the second species listed below might represent a distinct genus (William N. Eschmeyer, personal communication).

Jenkinsia lamprotaenia lamprotaenia (Gosse, 1851). Marine. Bermuda and Venezuela.

Jenkinsia lamprotaenia viridis (Bean, 1912). Marine. Florida, Leeward Islands, Campêche to Honduras.

Jenkinsia majua majua Whitehead, 1963. Marine. Campeche and Yucatan.

Jenkinsia majua woodsi Whitehead, 1963. Marine. Bahamas and Northwest coast of Caribbean.

3 SUBFAMILY ALOSINAE

Genus *Alosa* Linck, 1790. Shads. Including species previously placed in *Pomolobus* Rafinesque, 1820 (Svetovidov, 1964). All species anadromous but some populations confined to freshwater. Currently considered to contain six species in the Western Atlantic area (Hildebrand, 1964; Berry, 1964).

Alosa sapidissima (Wilson, 1811). American shad. Gulf of St. Lawrence to Florida; also Alaska to Baja California.

Alosa alabamae Jordan and Evermann, 1896. Alabama shad. Along the coast of the Gulf of Mexico from the Mississippi River to the Santa Fe River and in rivers from Arkansas to Iowa and West Virginia. *A. ohiensis* Evermann, 1902, is usually considered a junior synonym of *A. alabamae*, but adequate morphological comparisons have not been made from throughout the range of *A. alabamae*, and with the Atlantic and Pacific populations of *A. sapidissima*.

Alosa mediocris (Mitchell, 1814). Hickory shad. St. Johns River, Florida, to Maine and doubtfully from Campobello Island, New Brunswick (W.B. Scott, personal communication).

Alosa chrysochloris (Rafinesque, 1820). Skipjack herring. The Gulf of Mexico from Pensacola, Florida, to Corpus Christi, Texas, and in the Mississippi and Ohio rivers to Minnesota, Wisconsin, and Pennsylvania. This is a cognate of *A. mediocris* and the two species have not yet been morphologically distinguished.

Alosa aestivalis (Mitchell, 1814). Blueback herring. Cape Breton, Nova Scotia, to St. Johns River, Florida.

Alosa pseudoharengus (Wilson, 1811). Alewife. Newfoundland to South Carolina, and landlocked in the Great Lakes and some freshwaters of New York and New England. Definitive characters are lacking for absolute and easy separation of all specimens of *A. pseudoharengus* from *A. aestivalis*.

Genus *Brevoortia* Gill, 1861, Menhadens. Marine and estuarine. Confined to the Western Atlantic. Apparently five species with two hybrid pairs. The taxonomy was recently revised (Dahlberg, MS), and biological research continues (John W. Reintjes, personal communication).

Brevoortia tyrannus (Latrobe, 1802). Atlantic menhaden. Nova Scotia to Jupiter Inlet, Florida. A cognate of the Gulf of Mexico *B. patronus* and apparently hybridizing with *B. smithi* in Georgia and on the Atlantic coast of Florida.

Brevoortia patronus Goode, 1879. Large-scale menhaden. Gulf of Campeche to Caloosahatchee River, Florida, possibly to Florida Bay. Apparently hybridizing with *B. smithi* from Florida Bay to Port St. Joe, Florida.

Brevoortia smithi Hildebrand, 1941. Yellowfin menhaden. North Carolina to Louisiana, with a possible hiatus between Biscayne Bay and Florida Bay; adults may not range further west than Alabama.

Brevoortia gunteri Hildebrand, 1948. Finescale menhaden. Chandeleur Sound, Louisiana, to the Gulf of Campeche, possibly around the Yucatan Peninsula and into the Caribbean Sea, and possibly as juveniles eastward to Alabama.

Brevoortia aurea (Agassiz, 1829). Bahia, Brazil, to Bahia Blanca, Argentina. A cognate of *B. tyrannus* and apparently a senior synonym of *B. pectinata* (Jenyns, 1842).

4 SUBFAMILY CLUPEINAE

Genus *Clupea* Linnaeus, 1758. Marine; some races estuarine. A temperate-subpolar genus, restricted in a recent revision to one northern hemisphere species and one species off Chile (Whitehead, 1964).

Clupea harengus harengus Linnaeus, 1758. Atlantic herring. Labrador to Cape Hatteras in the Western Atlantic, extending eastward to Greenland, Iceland, and Northern Europe from Spitsbergen to the Straits of Gibraltar. Generally accepted as subspecifically distinct from the Northern Pacific *C. h. pallasi* Valenciennes, 1847, although a detailed, convincing analysis of the relationship of these two forms has never been published. The racial differences between stocks of Atlantic herring in the Gulf of Maine are under study by the Bureau of Commercial Fisheries Boothbay Harbor Biological Laboratory (Vaughn Anthony, personal communication).

Genus *Sprattus* Girgensohn, 1846. Marine and estuarine. Five species were assigned to the genus in a recent revision (Whitehead, 1964): the one that occurs in the Western Atlantic was previously placed in the genus *Clupea*.

Sprattus fuegensis (Jenyns, 1842). Straits of Magellan, Patagonia, Falkland Islands. It has been suggested (Whitehead, 1964) that *S. bassensis* (McCulloch, 1911) from southern Australia and Tasmania may be a junior synonym of *S. fuegensis*.

Genus *Ramnogaster* Whitehead, 1964. Marine, estuarine, and freshwater. A genus recently established as distinct from *Clupea*, and containing three species from southern Brazil and Argentina that may be only subspecifically distinct (Whitehead, 1964). The last review of these three forms was limited (De Buen, 1952); additional research is needed.

Ramnogaster arcuata (Jenyns, 1842).

Ramnogaster melanostoma (Eigenmann, 1907).

Ramnogaster pallida (De Buen, 1952).

Genus *Lile* Jordan and Evermann, 1896. Confined to American waters. One species each in the Eastern Pacific and the Western Atlantic.

Lile piquitinga (Schreiner and Miranda Ribeiro, 1903). Atlantic spottail herring. Marine. Vitoria, Brazil, to Margarita Island, Venezuela. *L. stolifera* (Jordan and Gilbert, 1881) of the Eastern Pacific is a cognate species. Taxonomic research on the two species is in progress by John E. Randall and me.

Genus *Platanichthys* Whitehead, 1968. One species.

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Platanichthys platana (Regan, 1917). Plate herring. Estuarine and freshwater. River Plate, Uruguay.

Genus *Rhinosardinia* Eigenmann, 1912. Confined to Northern and Northeastern South America. Currently considered to consist of three species, not adequately studied or compared. I have examined specimens of this genus whose characters are not in agreement with conclusions of the most recent revision (Hildebrand, 1964).

Rhinosardinia bahiensis (Steindachner, 1879). Marine. Rio de Janeiro to Bahia, Brazil.

Rhinosardinia amazonica (Steindachner, 1879). Para, Brazil.

Rhinosardinia serrata Eigenmann, 1912. Estuarine and freshwater. Venezuela to Surinam. I suspect that *R. pernambucana* Schreiner and Miranda Ribeiro, 1903, from Pernambuco, Brazil, is a senior synonym of *R. serrata*, and that both these nominal species may be junior synonyms of *R. amazonica*.

Genus *Harengula* Valenciennes, 1847. Tropical herrings. Confined to marine and estuarine waters of the tropical and subtropical Western Atlantic (apparently three species) and eastern Pacific (two species).

Harengula humeralis (Cuvier, 1829). Redear herring; redear sardine. Known from Florida, Yucatan, Honduras, and Venezuela; possibly continuously distributed through the West Indies, at Bermuda. This species is distinguished from other species of *Harengula* to small sizes by the relatively narrow band of teeth on its tongue and its deciduous scales.

Harengula clupeola (Cuvier, 1829). False pilchard. Reported from southern Florida, the West Indies, and Yucatan to Brazil. Apparently this is a valid species, but it has not been adequately distinguished from *H. pensacolae*. Characteristic specimens have fewer gillrakers and less deep bodies than *H. pensacolae*, but other specimens overlap and are not specifically identifiable.

Harengula pensacolae Goode and Bean, 1879. Scaled herring; scaled sardine. Reported from New Jersey to Brazil and through the West Indies. This species has not been adequately studied and compared throughout its range. Probably it is distinct from *H. clupeola*, and possibly two or three species are now recognized under the name *H. pensacolae*.

Genus *Opisthonema* Gill, 1861. Thread herrings. Confined to marine and estuarine waters of the tropical to temperate Americas. One Western Atlantic and four eastern Pacific species reported in the most recent review (Berry and Barrett, 1963).

Opisthonema oglinum (LeSueur, 1818). Fig. 1. Atlantic thread herring. Apparently a continuous distribution in continental waters and from the Gulf of Maine to Florianopolis, Brazil; through the West Indies; and at Bermuda. I have examined three collections of specimens from Colombia whose relatively shallow bodies and low gillraker counts suggest the existence of a second Western Atlantic species. Morphological differences found in specimens from other areas suggest either morphological races with pronounced environmental modification of characters, or the existence of sibling species.

Genus *Sardinella* Valenciennes, 1847. Spanish sardines. Marine. Western and Eastern Atlantic, Indian Ocean, and western and central Pacific. In none of these areas has the genus been adequately studied or the species compositions convincingly defined. Taxonomic work on the Western Atlantic forms is in progress by Charles M. Roithmayr (personal communication) and at the Tropical Atlantic Biological Laboratory. Three Western Atlantic species were recognized in the last revision (Hildebrand, 1964); the names are diagnosed below.

Sardinella anchovia Valenciennes, 1847. Fig. 2. I consider this to be specifically distinct from *S. aurita* Valenciennes, 1847, of the Mediterranean and Eastern Atlantic. Possible continuous distribution, both inshore along the continents and through the West Indies, from Massachusetts to Northern Argentina. Differentiated from *S. brasiliensis* by relatively fewer gillrakers, a shorter head and less deep opercle, and a less deep and less compressed body. Two or more species actually may be included within our current concept of *S. anchovia*.

Sardinella brasiliensis (Steindachner, 1879). Known from scattered records from the Gulf of Mexico, the West Indies, and the Northern coast of South America to Southern Brazil. Apparently specifically distinct from *S. anchovia* as discussed above, but some overlapping exists in all the separating characters. The scientific name was subjectively applied without reference to the type specimens and may not relate to the existing concept of this species.

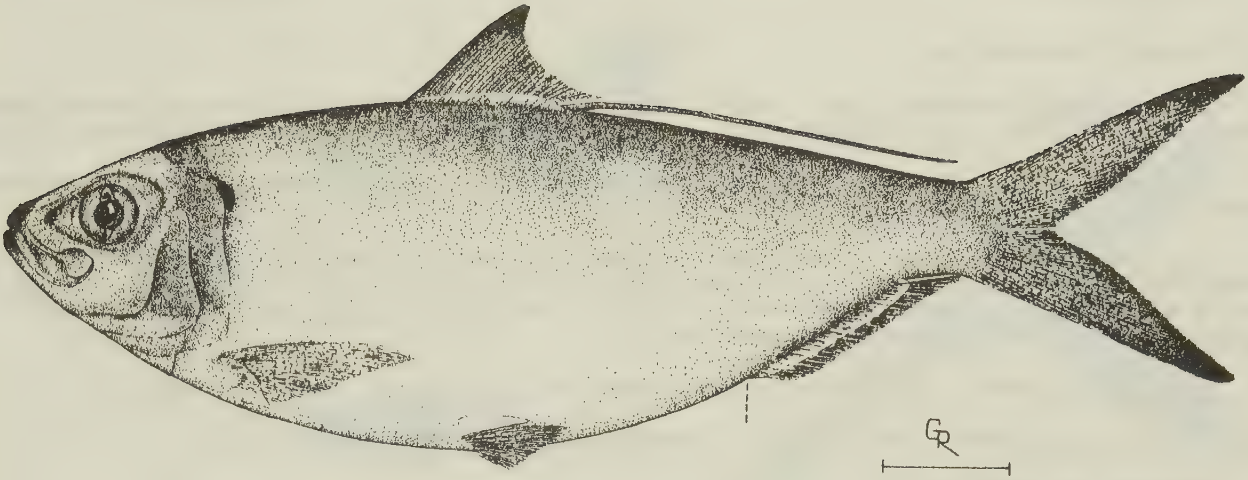

Fig. 1 Opisthonema oglinum (Le Sueur, 1818)

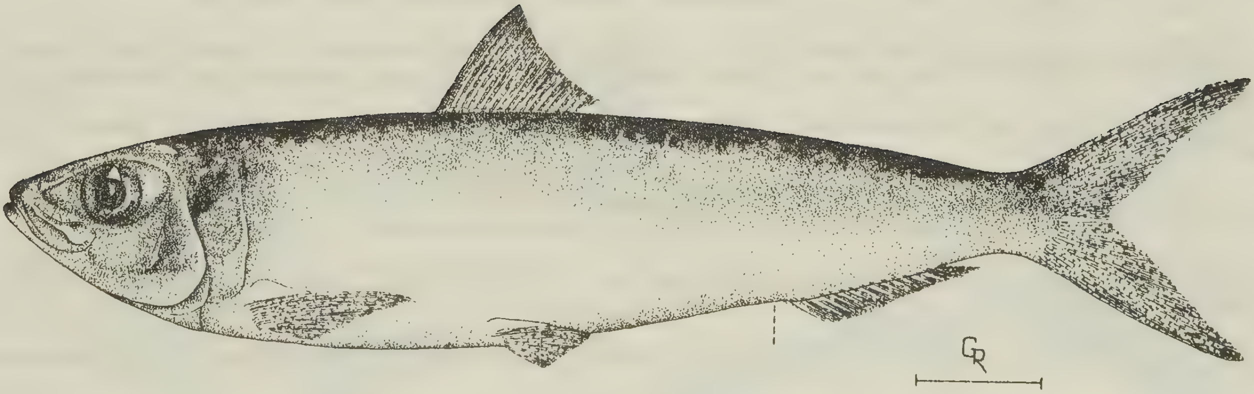

Fig. 2 Sardinella anchovia Valenciennes, 1847

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Sardinella pinnula Bean, 1912. Endemic to Bermuda. Closely related to S. anchovia, or possibly the same species.

5 SUBFAMILY DOROSOMATINAE

Genus Dorosoma Rafinesque, 1820. Gizzard shads. Freshwater, entering estuarine and marine waters. One species in Mexico Pacific drainage and four species in Atlantic drainage of North and Central America.

Dorosoma cepedianum (LeSueur, 1818). Eastern gizzard shad. Canada to Rio Pánuco in Eastern North America.

Dorosoma petenense (Günter, 1866). Threadfin shad. Kentucky and Southern Indiana to Oklahoma, Texas, Florida, Mexico, Guatemala, and British Honduras. Previously referred to as Signalosa petenense. The possibility exists (Minckley and Krumholz, 1960) of hybridization between this species and D. cepedianum, but it has not been fully demonstrated.

Dorosoma anale Meek, 1904. Rio Papaloapán, Mexico to Rio Usumacinta Basin, Guatemala.

Dorosoma chavesi Meek, 1907. Basins of Lakes Managua and Nicaragua, Nicaragua.

6 SUBFAMILY PRISTIGASTERINAE

Genus Pristigaster Cuvier, 1817. A single species.

Pristigaster cayana Cuvier, 1829. Fig. 3. Coastal and freshwater. Guianas to Brazil and Amazon drainage of Peru.

Genus Ilisha Richardson, 1846. Marine, estuarine, and freshwater. About 7 to 12 species, generally inadequately defined, in the Indo-West-Pacific area; one species each in the eastern Pacific, Eastern Atlantic, and Western Atlantic. The validity of I. narragansetae Fowler, 1911, described as taken off Rhode Island, is doubtful but still unexplained.

Ilisha amazonica (Miranda Ribeiro, 1923). Amazon drainage of Brazil and Peru.

Genus Pellona Valenciennes, 1847. Marine and freshwater. Possibly four species in the tropical Western Atlantic and apparently a single species in the Indo-West-Pacific. None of the species have been adequately studied or compared.

Pellona altamazonica Cope, 1872. Freshwater. Amazon drainage of Brazil and Peru.

Pellona castelnaeana Valenciennes, 1847. Fig. 4. Coastal and freshwater. Orinoco River, Venezuela, to Amazon River, Brazil. This may be a junior synonym of P. flavipinnis (suggested by Whitehead, 1967).

Pellona flavipinnis (Valenciennes, 1837). Coastal and freshwater. Rio de Janeiro, Brazil, to Rosario, Argentina.

Pellona harroweri (Fowler, 1917). Marine. Honduras to Southern Brazil. P. paulistana (Miranda Ribeiro, 1918), described from São Paulo, Brazil, is a junior synonym of P. harroweri.

Genus Neoopisthopterus Hildebrand, 1948. Marine. One Eastern Pacific and one Western Atlantic species.

Neoopisthopterus cubanus Hildebrand, 1948. Reported only from the type collection, six specimens from Cuba.

Genus Odontognathus Lacepède, 1800. Marine. One Eastern Pacific and two Western Atlantic species.

Odontognathus mucronatus Lacepède, 1800. Venezuela to near Amazon mouth, Brazil.

Odontognathus compressus Meek and Hildebrand, 1923. Costa Rica to Venezuela.

Genus Chirocentrodon Günther, 1868. Marine. A single species.

Chirocentrodon bleekerianus (Poey, 1867). West Indies, Honduras, and Panama to São Paulo, Brazil.

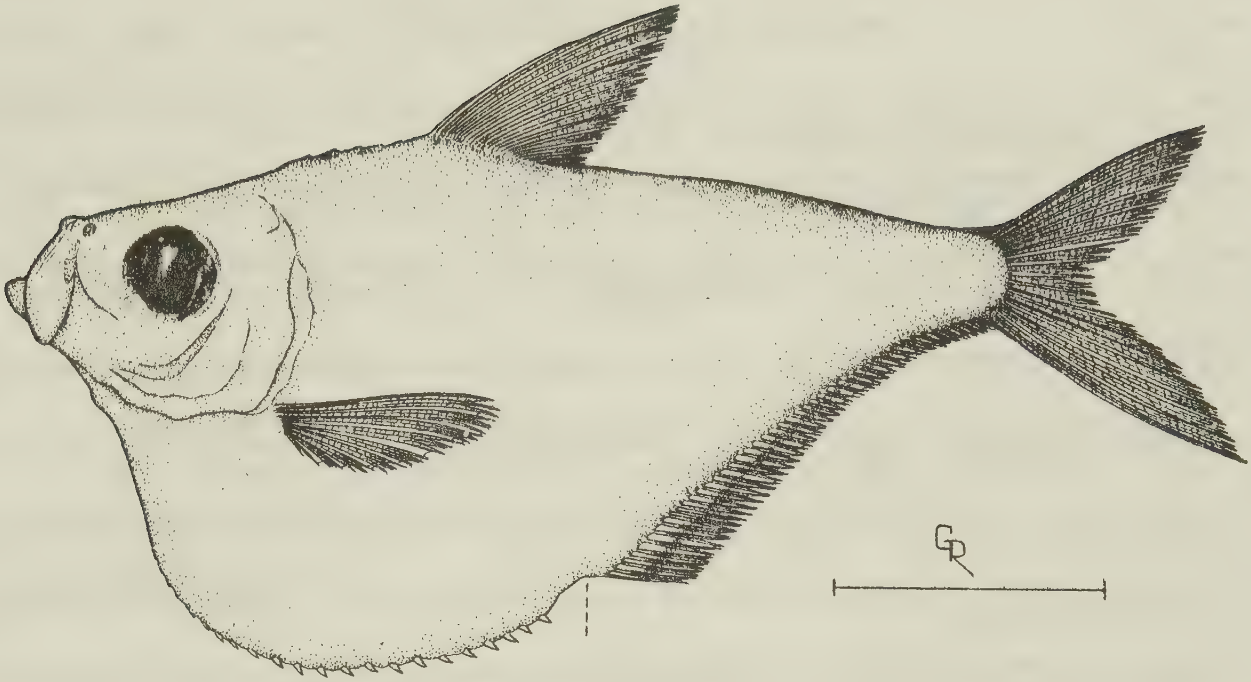

Fig. 3 Pristigaster cayana Cuvier, 1829

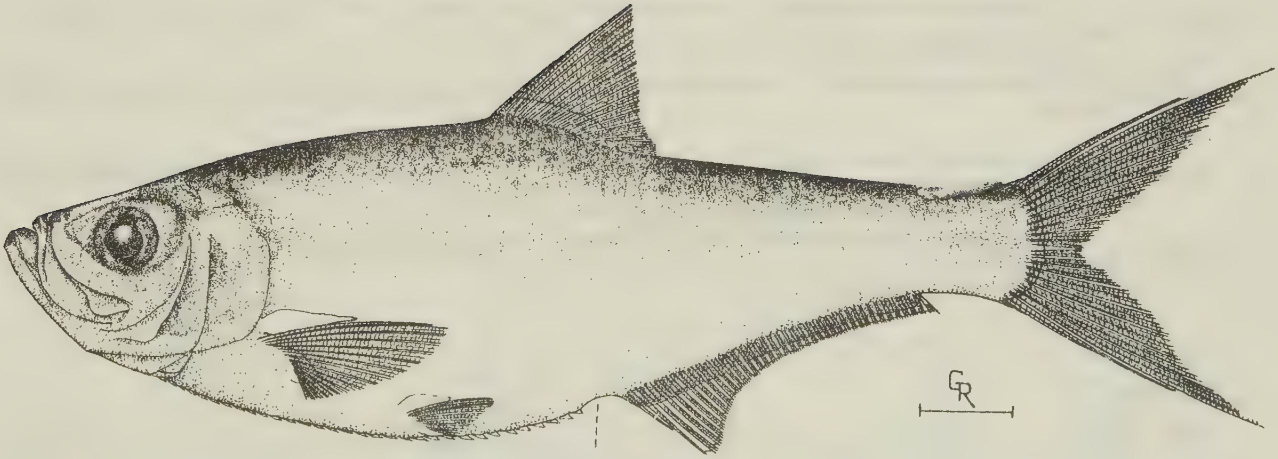

Fig. 4 Pellona castelnaeana Valenciennes, 1847

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ESCALA DE COLORES PARA EL ESTUDIO DEL CICLO REPRODUCTOR DE LA LANGOSTA *Panulirus argus* (Latreille) EN EL AREA DEL MAR CARIBE

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1 INTRODUCCION

Durante el año 1965 (FAO, 1966) se capturaron 17.400 toneladas de langosta *P. argus* en su área de distribución geográfica, desde las Bermudas al Brasil. Esta captura representa el 31.6 por ciento del total mundial de langostas de la familia Palinuridae y el 18.9 por ciento del total de langostas de todo tipo.

La importancia económica de esta pesquería ha motivado su regulación, la cual se basa en períodos de veda, tallas mínimas de reclutamiento pesquero y prohibición de captura de las hembras con hueva (Smith, 1959).

2 COMPORTAMIENTO BIOLOGICO DE LA ESPECIE EN SU AREA DE DISTRIBUCION GEOGRAFICA

La talla de su primera reproducción, aunque influída por la temperatura del agua (Sutcliffe, 1957), es bastante semejante para toda el área, pudiendo ser el muestreo efectuado en cada zona el causante de las variaciones observadas (Cuadro I).

CUADRO I

Tallas de primera reproducción (hembras con hueva)

AREA	AUTOR	TALLA (largo total en mm)
Brasil	Buesa *et al.*, 1968	161-170
Puerto Rico	Feliciano, 1957	229
Cuba	Buesa *et al.*, 1968	151-160
Florida	Dawson, 1949	152
Caribe	Butler, *et al.*, 1965	210
Bermudas	Creaser, 1950	229

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La máxima reproducción de la especie corresponde al período de marzo a julio, habiendo casos de hembras con hueva durante todo el año y señalándose en muchos casos la presencia de dos fases reproductoras consecutivas (Cuadro II).

CUADRO II

Duración del ciclo reproductor principal

AREA	AUTOR	DESDE	HASTA	MAXIMO
Brasil	Buesa *et al.*, 1968	febrero	mayo	marzo
Martinica	Anónimo, 1956	febrero	mayo	-
Puerto Rico	Mattox, 1952 Feliciano, 1957	febrero	julio	abril
Venezuela	Khandker, 1964	-	-	junio-julio
Cuba	Buesa *et al.*, 1968	marzo	junio	abril-mayo
Florida y Bahamas	Dawson *et al.*, 1951	marzo	julio	abril
Bermudas	Sutcliffe, MS	mayo	julio	junio

Los datos del poder reproductor de la especie (Cuadro III) son semejantes para diferentes áreas.

CUADRO III

Número de huevos por hueva, por largos totales (mm)

LARGO	BRASIL	CUBA	FLORIDA
299 mm	0.3×10^6	$0.2-0.4 \times 10^6$	0.5×10^6
254 mm	0.5×10^6	$0.3-0.5 \times 10^6$	0.5×10^6
292 mm	0.7×10^6	$0.4-0.8 \times 10^6$	0.7×10^6
AUTOR	Alves *et al.*, MS	Buesa, MS	Crawford *et* al., 1922 Dawson, 1949 Smith, 1948

Podemos señalar que la langosta *P. argus* presenta un comportamiento biológico bastante uniforme en su área de distribución geográfica.

3 ESCALA DE COLORES PARA OVARIOS

El ciclo de reproducción de la especie se viene estudiando en Cuba desde 1965 mediante una escala donde aparecen las diferentes coloraciones que van adquiriendo los ovarios desde la fase de reposo hasta la preovulatoria (Buesa, MS). Esta escala, con ligeras variaciones, se comenzó a ensayar en el Brasil a partir de 1966 para el estudio de los ciclos de reproducción de *P. argus* y *P. laevicauda*.

Las fases del desarrollo pueden agruparse como sigue:

FASE	ESTADIO DE LOS OVARIOS	CODIGO DE COLORES (Villalobos et al., 1947)
I	reposo (regresión)	YYO-19-6°
II	inicio del desarrollo	N 20 Y-19-9°
III	desarrollo medio	YYO-19-9° YYO-18-10° O-15-12°
IV	desarrollo final (preovulatorio)	SO-13-12° SSO-10-12° RS- 7-10°

4 CONCLUSIONES Y RECOMENDACIONES

1 - P. argus se comporta biológicamente de una manera bastante uniforme en todo el área del Mar Caribe;

2 - se hace necesario efectuar un estudio regional para determinar las épocas de maduración de la especie y por ende las de nacimiento de las larvas, relacionando la información que se obtenga con la teoría planteada por Ingle et al., (1963) acerca del origen de las poblaciones de P. argus de la Florida a partir de reproductores situados en el Mar Caribe;

3 - el inicio y duración del ciclo de reproducción podrán ser determinados facilmente con la escala de colores que proponemos.

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OBSERVATIONS ON NIGHT-LIGHT FISH ATTRACTION AND EXPERIMENTAL FISH PUMPING IN THE EASTERN CARIBBEAN SEA

by

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The Caribbean Sea fauna is relatively rich, both in species and numbers of small clupeoid fishes. Although most of these fishes are small they are ubiquitous, and their growth is rapid. They are basic plankton feeders, which means they are low on the food chain.

The usually narrow continental shelves of the island arc of the Caribbean Sea are mostly rocky and coralline making commercial trawling and the use of gill nets virtually impossible. In the Windward Islands, there are few beaches that would permit beach seining schools of small fish present in the near-shore waters. Field studies were conducted by the R.V. OREGON in the eastern Caribbean Sea to test a promising method of harvesting pelagic schools of small anchovy, herring, and sardine in shallow island waters.

Extensive observations were made on the attraction of small schooling fishes to night-lights and their susceptibility to capture with an experimental 6-in (1 500 gpm) fish pump. A total of 17 nights were devoted to these studies at the Windward Islands. Submerged 1 000-W lights were employed in combinations of from 1 to 4 units with precise intensity control. Species showing direct positive response to various light intensities included Anchoa lyolepis, Anchoviella eurystole, Jenkinsia sp., Membras sp., Harengula clupeola, H. humeralis, and Chirocentrodon bleekerianus, all of which appeared in dense concentrations at various times during the observations. Species showing indirect positive response included Opisthonema oglinum, Decapterus macarellus, Trachurus sp., and several other carangids. All of these exhibited some degree of susceptibility to fish pump capture. In addition, incidental captures of larger fishes included miscellaneous flyingfishes and large cutlassfish. Highest sustained catch rates were made at Grenada where in 1 hour 234 lb of anchovies and sardines were pumped at the rate of 900-1 800 fish per second. Samples of the most abundant species were sun-dried and analyzed for protein and oil content. Oil varied between 5 and 10 percent, whereas protein ranged between 34 and 68 percent.

There is relatively little known of the upper-level food chain productivity of the island and reef areas of the Gulf of Mexico and the Caribbean Sea. Most attempts to assess the potential commercial fishery value of these areas have resulted in discouraging estimations of yield. On the other hand, periodic observations on schooling phenomenon have generated numerous questions in the minds of fishery scientists experienced in these waters regarding this low yield hypothesis.

The abundance of species for shallow-water depths in the Gulf and Caribbean is well known. Most of these species are very small and widely distributed. These observations of dense schools and the frequent appearance of these species in stomach contents of predators have indicated that perhaps new exploratory techniques would be required to obtain meaningful and consistent quantitative estimations of population densities and availability.

Since 1950 an approach to this problem has been undertaken on the Bureau of Commercial Fisheries R.V. OREGON utilizing night-light attraction techniques and sampling with dip nets, trap lift nets, and small mesh purse seines. Attempts to standardize observation and sampling techniques were generally unsatisfactory; however, the vast accumulation of observational and catch data and the experience gained in conducting these activities have provided some highly subjective estimations on the response behaviour, density, and distribution of a number of pelagic schooling species of fishes.

One of the experiments attempting to standardize observational and collection techniques was conducted on OREGON Cruise #107 during February to April 1966. The cruise was designed to conduct a series of light attraction stations throughout the Lesser Antilles utilizing an experimental 6-in hose diameter, 1 500-gal/min fish pump as a collection device. A total of 17 night-light stations were occupied at anchor in the lee of 12 islands ranging from Trinidad to the south of St. John's, Virgin Islands on the north.

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Fish pumping occurred from dusk to dawn. Submerged 1 000-W lights were employed in combinations of 1-4 units each capable of light intensity controls. The lights were mounted to the intake nozzle of the 6-in hose. The hose and nozzle, with lights, were suspended in the water from a boom and could be held just under the surface to as deep as 3 fathoms. Any resulting catches were pumped into a large nylon marquisette retainer net suspended on the stern of the vessel.

Prior to our brief discussion of the various fish captures, it should be pointed out that during each night a series of controlled experiments were undertaken varying the depth of the nozzle in relation to the surface and the number and intensity of lights used for standard 20-min observation periods. The results of these attempts at standardization yielded little that would lend to statistical correlation and the scientific staff aboard the OREGON found it was as subjectively involved in assessing the results as we had been prior to conducting the experiments.

However, apart from the controlled experiments, numerous variations in hose position and changing of light intensity were tried with occasional spectacular although inexplicable results.

All told, approximately 200 species of fishes were collected during the 17 nights of tests. Also, approximately 25 species of crustaceans and about 10 species of squid were captured. Of the fish species, approximately half of the captures were limited to such small numbers that taking them with the light-pump array may be considered accidental. Of the remaining 100 species rarely more than 25 were captured during a given night at a given locality. Approximately 50 of the species were captured in either sufficient quantity or in repetitive sets as to at least provide some indication that they were responsive to the lighting configurations applied and susceptible to capture by pumping.

An experimental electrode array that had been designed to enhance fishing efficiency of the pumping operation experienced serious malfunction early in the cruise and provided no conclusive contributions to these observations.

The 50 or so species that we considered to be responsive in these tests can be placed into four broad categories:

1. Inshore schooling species; primarily anchovies, sardines, herrings, dwarf herrings, and silversides, etc.

2. The inshore night predators; primarily carangids of the genera Caranx, Decapterus, and Selar.

3. The oceanic pelagics; primarily flyingfishes, myctophids, etc.

4. A large number of juvenile and young bottom and reef fishes such as mullids, holocentrids, priacanthids, serranids, acanthurids, etc.

By dividing the night-time period into three very generalized periods it is possible to depict some of the behaviour characteristics of these four groups that will provide some sort of bases for subsequent discussions. These periods can be defined as post-sunset, middle-of-the-night, and pre-sunrise. Post-sunset behaviour patterns developed and phased out within a period of 2-4 h after sunset; pre-sunrise behaviour patterns developed from 1½ to ½ h before sunrise. The "middle" period would range between the end of the post-sunset and the initiation of the pre-sunrise periods.

The species of particular interest in these studies, the inshore schooling group, appears to have four characteristic behaviour patterns relating to night-light attraction. During OREGON Cruise #107 this group most frequently showed up in the post-sunset period, disappeared during the middle period, and returned in very heavy densities during the pre-sunrise period. Equally common were heavy concentrations only during the pre-sunrise period. Less common was the appearance of species of this group that maintained relatively heavy concentrations throughout the night. Lastly were the appearances of small aggregations during the post-sunset period that either disappeared toward the middle of the night or were erradicated or scattered by predator attacks.

The next group in priority of commercial interest, the inshore night predators, would generally appear in some way associated with the patterns described above for the inshore schooling species. Perhaps a notable exception would be during the pre-sunrise period when heavy predation diminished entirely.

The appearances of oceanic species such as the flyingfishes and myctophids appear to coincide with greatly diminished activities of the preceeding two groups. Less precisely defined was the appearance of juvenile and young bottom and reef fish species whose concentrations waxed and waned almost randomly but only appearing in large numbers when heavy densities of all other groups were absent.

Perhaps the most dramatic phenomenon observed was the initiation of "pre-dawn swarming" within a half-an-hour of dawn. Our observations of this activity were confined to the dark half of the moon phase. Species observed in such "pre-dawn swarms" included the spiny toothed herring, Chirocentrodon bleekerianus at Chaguaramas Bay, Trinidad; the dwarf herring, Jenkinsia lamprotaenia at St. John's Island; the dusky anchovy, Anchoa lyolepis and the false pilchard, Harengula clupeola at Beau Sejour Bay, Grenada; and the rough silverside, Membras sp., at Portsmouth Bay, Dominica. All of these species exhibited a considerable degree of susceptibility to capture by the fish pump.

The initial observations on "pre-dawn swarming" took place the night of 26 February at Anguilla Island. An abstract of the observation log and catch summary sheets for this night is given in Table I, which exemplifies but certainly does not typify the night-long species successions observed during the cruise. Aside from the standard of pumping, tests were occupied with steady pumping with the hose nozzle 18 ft below the surface and all four lights at full intensity. At 05.15 h a solid slug of Anchoa lyolepis came through the hose within an interval of 1 or 2 seconds. The catch weighed a total of 40 lb and the species was not recorded during the pumping prior to this capture. Subsequently, particular attention was paid to the pre-dawn period at a number of other locations and a multitude of light intensity changes were tested. It was found that, during the pre-dawn period, by gradually reducing the light intensity within a period of several minutes, the milling schools of several species could be brought into close proximity to the nozzle where catches would reach several pounds/minute. Then by instantaneously increasing light intensity the entire schooling array was frightened and dispersed beyond the limits of visibility. However, within a period of 10-30 sec following this event, massive swarms of the same species would exhibit reverse behaviour and rush to the lights, frequently causing total extinction of illumination. When this could be effected, catch rates would accelerate up to 25 or more pounds/minute. These concentrations around the lights were so dense that, on occasions, masses of fish were forced out of the water to a height of several inches. Following this rather violent action, the schools would form amoeboid shapes and begin large erratic milling turns around the light. The entire cycle was repeatable every 5-10 minute. One series of three subsequent variations in light intensity as described above yielded 170 lb of anchovies and a subsequent sequence produced 36 lb of scaled sardines.

Samples of the more abundant species attracted and caught were sun-dried aboard the OREGON and later analyzed for protein and oil content by the Bureau's Technology Laboratory at Pascagoula. Protein values ranged between 40 and 68 percent for those species that could be considered desirable foodfish. Oil content ranged between 5 and 9 percent.

While nothing conclusive could be derived from the data accumulated from these tests, many new and previously unreported behaviour characteristics were observed and many species previously unrecorded from the area were noted. Some of these appear to be present in far greater numbers than could be estimated from any prior indications. We feel that night-light fish pumping could play an important role in the future explorations of the fishery resources of the Caribbean Sea. Further, with the addition of an electrical field that would permit more meaningful sampling of the aggregations within the light fields, and by using larger capacity pumps, catches of several tons/night could well be expected from a number of island and reef areas heretofore considered impoverished of fishery resources. Certainly, the questions of potential sustainable yield stands in the forefront of this assumption; nevertheless, this seems to be a fruitful area for future explorations and study.

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TABLE I

Sequential observations and fish pump captures of major fish species under night-lights at Anguilla Island, West Indies, during the night of 26-27 February 1966

Species	20.00-22.00 hours	22.00-24.00 hours	24.00-02.00 hours	02.00-04.00 hours	04.00-06.00 hours
Caranx latus					
Observed	abundant	many	few	none	none
Caught	none	(pump off)	none	none	none
Decapterus punctatus					
Observed	none	many	schooling	schooling	few
Caught	none	(pump off)	20 lb	10 lb	1 lb
Trachurus lathami					
Observed	none	none	none	few	few
Caught	none	(pump off)	none	none	1 lb
Membras sp.					
Observed	abundant	few	none	few	few
Caught	20 lb	(pump off)	none	1 lb	1 lb
Anchoa lyolepis					
Observed	none	none	none	none	none
Caught	none	(pump off)	none	none	40 lb
Harengula clupeola					
Observed	few	none	none	none	none
Caught	2 lb	(pump off)	none	none	3 lb
Jenkinsia lamprotaenia					
Observed	lg school	none	none	none	none
Caught	30 lb	(pump off)	none	none	2 lb
leptocephali					
Observed	abundant	abundant	few	none	none
Caught	16 lb	(pump off)	none	none	none
Priacanthus arenatus (juv.)					
Observed	none	none	none	none	thousands
Caught	2	(pump off)	5	10	1 003

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A GENERAL RESUME OF OREGON CARIBBEAN FISHERY EXPLORATIONS 1955-1967

by

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1 INTRODUCTION

Since 1955, 16 cruises of the Bureau of Commercial Fisheries vessel, OREGON, and one cruise of the chartered vessel, SILVER BAY, have been devoted to exploration of Caribbean and tropical West Atlantic fishery resources, exclusive of work carried out in the Bahamas. In the course of these cruises, over 1 500 fishing stations were occupied. Table I breaks these down for major gear types and general areas in the Caribbean Sea proper. In addition, there were several hundred shrimp and fish trawl stations in the area off north-west South America.

These exploratory cruises, with few exceptions, have been largely concerned with gaining a generalized picture of the total resource potential that would be available to longlines, trawls, dredges, and bottom lines. A detailed faunal inventory has accompanied the investigations as well which has provided material for about one hundred papers of varying scientific content, including several master's theses and doctoral dissertations. Also, a more detailed exploratory study of the shrimp resources off the Guianas has resulted in the development of a major fishery. This preliminary field work is now complete and with the Bureau of Commerical Fisheries new research vessel, OREGON II, we have begun additional detailed studies on specific species or species groups considered important to future fishery development. Such work will involve precise definition of grounds, gear trials, simulated commercial fishing effort, demonstration landings, demonstration cruises, and reporting of results.

This paper provides a backward glance at what has been done and what has been found in the way of apparent fishery resource potentials. For convenience, we have divided the Caribbean into the four general areas indicated in Table I and have treated the seemingly outstanding potentials of each, with notations on items of lesser interest as well.

2 AREA I - YUCATAN CHANNEL TO THE CANAL ZONE

This area, which includes the waters contiguous to British Honduras, Honduras, Nicaragua, and western Panama, has been investigated during segments of five OREGON cruises with tuna longlined, shrimp trawls, dredges, and bottom lines as principal gear.

The western Caribbean, from the Yucatan Straits to the Canal Zone, is, by and large a rough-bottom area of reefs and islands, coral, and shell - an ideal habitat for snapper, grouper, and associated species. These fishes offer one of the two obvious potentials in this area, excluding the inshore shrimp fisheries which are beyond the bounds of this paper. Most of the OREGON explorations

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on bottom resources have been conducted with shrimp trawls not ideally suited either to the rough bottoms or to efficiently catching larger fish. Frequent captures of young fish, however, have given preliminary indications of a relatively large snapper potential when compared to similar samples in proximity to established snapper grounds. These indications have been followed up to limited extent with traditional handline gear and reels which, in turn, have recently led several U.S. vessels to conduct initial commercial fishing trials. Although a wide variety of species is encompassed in the snapper and grouper genera present, our findings indicate that three species - silk or yelloweye snapper, blackfin snapper, and Caribbean red snapper - predominate in both trawl and line catches.

The second potential obvious in this area has been indicated by the frequently-observed surface schools of the smaller tuna species, primarily blackfin and skipjack. These, and less commonly, yellowfin tuna, are certainly abundant if not readily available to present gears. Blackfin tuna seem to be especially numerous in the area and some local production has been initiated in Honduras recently. However, the tuna stocks in this area are virtually untouched. It is important to note that the three species commonly occurring; blackfin, yellowfin, and skipjack, are all high-quality fish. The blackfin has recently been accepted by the U.S. Food and Drug Administration for labelling as light meat tuna, and industry test packs with samples supplied by our Base have proved to be of exceptionally high quality. Seining is probably the ultimate answer to dealing with these schools, although interim efforts at trolling could be rewarding. Attempts to fish blackfin tuna with live bait and jackpoles have so far proved discouraging, although bait is readily available in the area and a successful fishery exists in Cuba for taking very small blackfin.

Longline tuna catches in the northern portion of the area have invariably been light. Off Panama, however, longline catch rates have varied from 2.0 to 6.9 per 100 hooks fished with large yellowfin predominating in the catches.

Shrimp trawl explorations have indicated scattered royal-red shrimp, "megalops" shrimp, and scarlet prawn concentrations, but large commercially exploitable stocks are not evident. Another crustacean, the deep-water lobsterette, Nephrops binghami, has been taken along this coast in depths of 150-280 fm at times in rather large numbers. It would be a valuable supplement to deep-water fishing for other species, though there is no indication that it alone would support a sustained fishery.

While a number of localized spiny lobster fishing operations are found throughout this region, incidental captures in many additional reef areas indicate that there might be opportunities for extensive expansion of this fishery.

In summation, this area is rich in snapper and grouper resources that are currently underexploited and in a tuna resource composed of smaller surface schooling species that have not been tapped.

3 AREA II - CANAL ZONE TO MARGARITA ISLAND (VENEZUELA)

From the Canal Zone eastward along the southern Caribbean, the bottom topography and the associated fauna changes. Offshore, numerous schools of the small tunas were found; in fact, the largest individual schools observed in the Caribbean were sighted in this area. These stocks are totally unused. Their capture might present more problems than the stocks off Central America owing to rougher sea conditions that would interfere with present purse seining methods west of Guajira. Again, blackfin tuna predominate in all trolling catches and sightings. Here, earlier long-lining was relatively productive for yellowfin tuna, especially in proximity to Curaçao, and limited fishing off Guajira indicates the presence of seasonal swordfish concentrations. Shark catches on tuna long-lines are at least seasonally heavy. One 1 000-hook set off Guajira captured 103 dusky sharks weighing about 7½ tons. The shark density effect on longlining for yellowfin tuna would indicate disastrous predation but, as a separate resource, a number of species of sharks appear to hold good fishery promise.

Shrimp trawl explorations on the outer Continental Shelf have been interesting, though not conclusive. Potential fishing grounds for brown shrimp were located in the area between Pta. San Bernardo southward to the Gulf of Darien in 10-40 fm during a spring cruise off the Colombian Shelf in 1964. Time did not permit detailed examination of the area but night-time trawling resulted in catches indicative of concentrations of commercial value. A brief re-examination of the grounds 16 months later during the autumn of 1965 did not result in catches approaching those found in spring. A more intense exploration of the area is certainly indicated.

The shrimp fishery of the Gulf of Venezuela is well documented and needs no further mention here, being beyond the scope of our more offshore explorations. Elsewhere along the outer shelf off Venezuela, shrimp catches were light and scattered.

Incidental to shrimp catches, snapper and grouper in the shrimp nets indicate that follow-up work work with fish trawls in 60-100 fm along the entire coast might be productive although bottom trawling conditions are formidable, for the most part.

Deeper trawl drags yielded light catches of royal-red shrimp running to about 50 lb per drag off Santa Marta and immediately east of the Gulf of Venezuela - as well as "megalops" shrimp and small quantities of deep-water lobsterettes. Bottomfish catches in the upper slope zone were very light compared with catches from similar effort in the Gulf of Mexico and off the east coast of the United States.

The infrequent observations of sardine schools along Venezuela are probably indicative of the more offshore nature of our activities than any indication of the extent and magnitude of the resource.

In summary, both surface schooling and deeper-swimming tunas in the area encompassed between the Canal Zone and Margarita Island offer the most promise for development and smaller poorly-defined potentials exist for shrimp, snapper, and grouper.

4 AREA III - CUBA TO THE VIRGIN ISLANDS

Four OREGON cruises and one cruise of the chartered vessel, SILVER BAY, have been made to this area exclusive of cruises concerned with Bahamas' fauna.

The shelf and slope zones of the entire area are marked by extremely rough bottom, with sharp drop-offs on both sides of most of the islands - neither conducive to trawling. Off the north coast of Hispaniola, the SILVER BAY found trawlable bottom between 110 and 800 fm over one rather large area. The trawl drags completed here resulted in only light catches of royal-red shrimp and scarlet prawns. Extremely rugged bottom conditions prevailed in shallower depths. Around Jamaica, there are a few small areas where trawling can be carried out. Dragging on the south coast of Jamaica in shallow water resulted in small catches of pink shrimp and small snapper. The north coast is virtually untrawlable.

Puerto Rican waters are, for the most part, unsuitable for bottom trawling. The shallow-water areas where trawling could be accomplished close to the beaches are, from our experience, so heavily fished with fish and lobster traps as to make trawling similar to running an obstacle course.

Therefore, the area of greatest interest is the waters well above the bottom wherein, at least seasonally, are contained sizable schools of yellowfin, bluefin, blackfin, and bigeye tunas, skipjack, and albacore. Fishing with long-lines in the Windward Passage in spring resulted in yellowfin tuna catches of from 1.0 to 2.6 fish per 100 hooks, but fishing was poor in late winter and early summer. Numerous surface schools of blackfin and blackfin mixed with yellowfin and skipjack were observed and troll-sampled around Jamaica and western Puerto Rico during the spring and early summer.

It would appear that the potential of this area would lie in these pelagic resources rather than in its benthic resources. One notable exception, not investigated by us, would be the trap or pot fisheries for lobster and other benthos.

5 AREA IV - WINDWARD AND LEEWARD ISLANDS

Here again, we are considering an area marked by very rugged bottom configurations, with only scattered small grounds suitable for trawling. Snapper handlining from the Virgin Islands to Nevis Island indicated a large potential for silk snapper as did fishing north of the Virgins and on the bank edge north of Anguilla Island. None of these areas seem suitable for roller-rigged fish trawls, although further explorations will be carried out with this gear in the future. Bottom lines and some trawling around Dominica resulted in small catches of grunts and small vermilion snappers.

There are extensive surface schooling tuna stocks in this area. Also, the best longlining accomplished by the OREGON (22.4 yellowfin per 100 hooks fished) occurred off Aves Island. Good fishing in this area was later verified by extensive Japanese longlining which has reduced the stocks in this area appreciably.

Throughout the Lesser Antilles some concentrations of clupeoid and other schoolfishes suitable for both food and reduction uses are to be found. Many of these fishes can be readily attracted to night-lights about the islands, including representatives of the genera Anchoa, Anchoviella, Jenkinsia, Membras, Harengula, Chirocentrodon, Opisthonema, and Decapterus. Jacks (Carangidae) are also numerous. The OREGON's night-lighting efforts in the islands are the subject of a separate paper in this Symposium.

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In summary, the Caribbean unquestionably holds promise for expansion of fishery production. Outstanding resource potentials are inherent in the tunas and in the snapper and grouper complex. Swordfish, sharks, clupeoid fishes, and shrimp in some restricted areas are also possibilities. The OREGON surveys have been conducted with a view toward providing preliminary resource indications. This work is now being followed up by detailed studies centred on individual species and species groups.

TABLE I

Monthly exploratory fishing effort (numbers of stations) by principal gear types in four major regions of the Caribbean Sea

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Totals by Gear
I Yucatan to Canal Zone													
Shrimp Trawls	5	31		12	41	19		33	67			4	212
Scallop Dredge	4	7			10	27							48
Fish Trawl		3				6							9
Handlines	7	6			2					2			17
Longline	1			1	7			2	4				15
II Canal Zone to Margarita Island													
Shrimp Trawls				1	70	13			29	125			238
Scallop Dredge					8				5	31			44
Fish Trawl										15			15
Hand lines									1	3			4
Longline				5					4	1			10
III Cuba to Virgin Islands													
Shrimp Trawls			1		24	8	7	2	28	52	14	4	140
Scallop Dredge					12	10				8	19		49
Hand lines		2			9	3					1		15
Longline	7			13	4	5				6	1		36
IV Windward and Leeward Islands													
Shrimp Trawls		1	6	12	11	2			29				61
Scallop Dredge		5	13		3	3			34				58
Hand lines			6		3	2			1				12
Longline		2	2	4					10	1			19
TOTALS BY MONTH	24	57	28	48	204	98	7	37	212	244	35	8	

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FISHERY POTENTIAL FOR SNAPPER AND GROUPER IN THE CARIBBEAN AREA AND THE GUIANAS

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1 INTRODUCTION

The Caribbean has long been considered a relatively unproductive sea when compared with heavily fished, high production areas, such as the Grand Banks and the Sea of Azov. Production of a certain type of fishery, however, has long been used as a criterion for estimating fishery potential. Tropical fisheries do not necessarily lend themselves to comparisons with temperate fisheries when the same standards are used.

The Caribbean provides a more scattered and diverse fishery potential than temperate waters because of the greater number of species and wider variety of ecological areas. A major feature of Caribbean topography is the ruggedness of the shelf in the west and south, and the abundance of reefs and banks which dominate this shelf and slope and surround the eastern islands. Large numbers of species are found in areas of rugged bottom around the Caribbean but three families of fishes - the snappers, groupers and grunts - are the dominant carnivores.

Snappers often congregate in large schools and may be taken in large numbers when they are so located. Groupers are more solitary and tend to be widely scattered over an area. Grunts, which probably are even more abundant than snappers and groupers, have schooling tendencies, but appear to be scattered throughout any area of rugged bottom. Although the species composition changes with depth, most shelf regions of rough bottom in the Caribbean would produce at least one species from each family.

The purpose of this paper is to briefly review knowledge of snapper and grouper abundance and availability in the Caribbean Sea. The principal commercial species taken by the R.V. OREGON are listed in Table I with their common names, main adult depth range, and occurrence in specific areas. Zones used in Table I are shown in Figure 1.

2 PRESENT FISHERIES

The bulk of the snapper and grouper fishery is carried out locally from the port of landing. With the exception of Cuban fisheries, there is little organization among fishermen, and they are generally working independently, often at a bare subsistence level. Craft may be a one-man canoe or sailing vessel with a crew of two or more. Motorized craft are now coming into some usage, but are numerous only in a few areas. The length of a trip with small vessels is often limited by the need to return to port before the catch spoils (except for vessels with live-wells). Little effort, therefore, is expended on distant banks.

Most fishing is done with relatively slow and time-consuming handlining. Fish pots are widely used on shallow banks and reefs, particularly in the Antilles, but catches are not large enough to consider this a major fishery as yet.

TABLE I

Principal commercial species taken in the various faunal zones by the R.V. OREGON

Species	Common name	Faunal zones R.V. OREGON records	Main adults depth range (fm)
Epinephelus niveatus	Snowy grouper	11, 13, 14, 15	50–100
" *nigritus*	Warsaw grouper	11, 13, 16, 21	20–50
" *flavolimbatus*	Yellowedge grouper	13, 15, 16, 21	80–150
" *guttatus*	Red hind	10, 11, 13, 22, 24, 25	5–20
" *itajara*	Jewfish	13, 16	1–30
" *morio*	Red grouper	10, 11, 24, 25	5–40
" *mystacinus*	Moustache grouper	10, 11, 21, 24, 25	80–120
" *striatus*	Nassau grouper	22	1–40
" *adscensionis*	Speckled hind		10–30
Mycteroperca bonaci	Black grouper	11	1–30
" *falcata*	Scamp	14, 15, 16, 25	1–30
" *interstitialis*	Yellowmouth grouper	24	1–30
" *venenosa*	Yellowfin grouper	11, 22	1–30
Apsilus dentatus	Black snapper	10, 16, 24	80–120
Etelis oculatus	Queen snapper	10, 13, 14, 21–26	80–120
Lutjanus anilis	Mutton snapper	12–16, 22, 24	1–30
" *apodus*	Schoolmaster	13, 24	1–20
" *buccanella*	Blackfin snapper	10, 11, 13–16, 24, 25	50–100
" *griseus*	Gray snapper	10, 22	1–20
" *jocu*	Dog snapper	10, 11, 13	1–20
" *mahogoni*	Mahogany snapper	11, 16, 21	10–30
" *purpureus*	Caribbean red snapper	11, 13, 15, 16, 24, 25	20–50
" *synagris*	Lane snapper	11–16, 22–25	1–10
" *vivanus*	Silk snapper	10–13, 15, 16, 22–25	80–120
Ocyurus chrysurus	Yellowtail snapper	10, 11, 22, 23, 25	1–25
Pristipimoides sp.	Wenchman	10–16, 21–26	50–100
Rhomboplites aurorubens	Vermilion snapper	10–16, 22, 24, 25	50–100

Modernization of handling facilities is now taking place around some larger population centres in the Caribbean. This includes icing or freezing the catch, sanitary handling and fish markets, and improved transportation. However, a great percentage of the Caribbean area is still burdened by a lack of ice and holding space, poor handling of the product, and inadequate marketing facilities. A combination of all above-mentioned factors results in a product that is landed in small units, is in poor condition when landed, does not bring a good price, and is available only for local consumption.

3 EXPLORATORY RESULTS

Exploratory work for snappers has been conducted recently by the UNDP/FAO Caribbean Fishery Development Project, headquartered in Barbados. One of their vessels, the M.V. ALCYON, stationed in Jamaica, has worked extensively in the Pedro Bank area with handlines. Fish pots and bottom longlines have also been used to some degree by the ALCYON and the M.V. FREGATA. Explorations have included the Hispaniolan, Puerto Rican, and Lesser Antillian areas. Previous work by the R.V. OREGON has involved a broad survey to find indications of promising resources and some effort has been expended in almost every region of the Caribbean. Shrimp and fish trawls have been employed in most areas where the bottom is not too rugged, and handlines have been fished on most of the major bank and shelf complexes. A discussion of catches and trends of commercial potential for major Caribbean areas follows.

British Honduras (Zone 10). The Caribbean coasts of British Honduras, Guatemala, and northern Honduras comprise relatively little shelf area. Major concentrations of commercial species have been found along the seaward edge of the shelf with little being taken inshore, except for yellowtail snapper and some species of groupers. Handline stations between 12 and 100 fm have yielded light to moderate catches of black, queen, blackfin, gray, dog and silk snappers. Very little trawlable bottom exists in the area, and the limited shrimp trawling effort by the OREGON has yielded light catches of wenchman.

Honduras-Nicaragua (Zone 11). The Honduran-Nicaraguan shelf and island complex comprises by far the greatest amount of suitable bottom for snapper and grouper. The largest continuous stretch of trawlable bottom in the Caribbean is also found along the outer shelf and upper slope.

The major species being utilized at present is the silk snapper, caught at depths of 80-120 fm along the edge of the shelf. The American fleet is working the silk snapper resource and has had up to 33 vessels fishing off the Honduran-Nicaraguan shelf and associated banks. Catches of 30 000 to 40 000 lb per 21-day trip are not uncommon. In lesser depths, the Caribbean red snapper dominates from 20 to 50 fm with concentrations of blackfin snapper being found from 50 to 100 fm. In addition, OREGON handline catches between 5 and 80 fm have yielded mahogany, dog, lane and yellowtail snapper. Wenchman, vermilion snapper, Caribbean red snapper, lane snapper, and various grunts have been taken in fish and shrimp trawls, with lane snapper showing the greatest abundance. Grunts have been taken throughout the shelf in depths out to 75 fm.

The red hind and red grouper have been the predominate serranids in handline catches made on the shelf with snowy, yellowedge, and moustache groupers being taken along the outer edge of the shelf.

Costa Rica-Panama (Zone 12). Practically no shelf area exists off the Caribbean coasts of Costa Rica and Panama. Major development appears to depend on those species (principally silk snapper) that are abundant along the edge of the shelf. Limited trawling by the OREGON on this narrow shelf has resulted in light catches of lane snapper from 10 to 20 fm, and vermilion snapper from 50 to 150 fm.

Panama-West Colombia (Zone 13). Recent explorations by the U.S. snapper fleet have resulted in an expansion of fishing effort into the south-west Caribbean. Three vessels have been fishing the edge of the shelf off western Colombia for silk snapper in 100 to 125 fm. These smacks have made catches of 35 000 to 40 000 lb in five days of fishing.

Sections of the Colombian shelf have been worked with shrimp trawls by the OREGON, but large snapper catches in the trawls have been rather low. Lane snapper has been the predominate species, although mutton, silk, vermilion and Caribbean red snapper and wenchman catches have given some indication of abundance. Shallow banks from the Gulf of Darien to Barranquilla appear to be good grounds for yellowtail snapper. Yellowedge grouper has been the dominant major serranid in offshore trawl catches. Grunts have been scarce.

East Colombia (Zone 14). Little information is available on snapper and grouper abundance in the East Colombian region. Limited work on the shelf has shown that grunts predominate as the foodfish species caught incidentally in shrimp trawls. Lane snapper have been taken in limited quantities inside of 50 fm, with wenchman and vermilion snapper being most abundant from 50 to 125 fm.

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Venezuela (Zone 15). The tremendous number of banks and shoals located along the 1 750-mi coastline are too lightly fished to have produced more than a fraction of the potential available in snappers and groupers.

Catches have been relatively low on trawlable bottom off Venezuela, with grunts being the predominant group taken by OREGON shrimp trawling in 10 to 14 fm. Lane snapper and wenchman were taken in low abundance from 25 to 125 fm. The dominant deep-water serranid taken was the yellowedge grouper, from 30 to 100 fm.

Recent fish trawl explorations by the FAO vessel CALAMAR off eastern Venezuela from 20 to 65 fm resulted in low catches of marketable fishes. Snappers were taken at rates that do not appear to offer good trawling potential. The CALAMAR catches are equivalent in magnitude to the OREGON catches in the area. Trawl catches of snappers around Trinidad were also quite low.

Bottom longline sets in 18 to 110 fm around the leeward Netherlands Antilles produced snappers and groupers at a discouraging rate of 3 lb per 100 hooks.

Trinidad-Guianas (Zone 16). The extensive shelf off Guyana, Surinam, and French Guiana has been explored during three cruises of the OREGON and has had concentrated inshore coverage by the CALAMAR. Most OREGON work was conducted by shrimp trawls which yielded light catches of small snappers and grunts. North of Paramaribo, trawl catches of only 50 to 75 lb of wenchman (pink snapper) per hour were made between 25 and 30 fm. Seventeen fish trawling stations made in 15 to 20 fm yielded a bare 15 lb of Caribbean red snapper per hour. Over a 20- to 75-fm depth range off Surinam, the CALAMAR averaged 12 lb of snappers per hour. Catch rates were somewhat higher off French Guiana but still did not reach what FAO personnel felt to be concentrations that offered good potential to fish trawling. Warsaw and yellowedge groupers have been the dominant serranids taken in deep-water trawls (40 to 80 fm).

Cuba (Zone 21). The extent of development of the Cuban fisheries is not known at present. Articles in recent issues of the Cuban fisheries magazine "Mar y Pesca" (April and June 1967) discuss the development of fishery cooperatives and coordination of vessels to increase catch. The annual May run of lane snapper in the Gulf of Batabano was taken advantage of by 109 vessels from all over the island. Vessel catches up to 40 000 to 50 000 lb using nets were reported. The same procedure was followed during a grouper run in eastern Cuba in November. The grouper fishery was conducted with traps.

Major species taken by the Cuban snapper fishery are listed as grouper, yellowtail snapper, white grunt, and snapper. Cuban snapper and grouper stocks are probably being heavily utilized. Extension of Cuban fishing effort to Campeche Bank is documented for a number of years.

Jamaica (Zone 22). The principal trawl-caught foodfishes on OREGON explorations in the Jamaica area were grunts. Lane snapper were also taken in small numbers inside 25 fm, along with yellowtail snapper.

Valuable data on snapper have been gathered by the ALCYON on the Pedro Bank area south of Jamaica. Yellowtail snapper, the most desirable Jamaican market fish, is apparently quite abundant around shallow areas on Pedro Bank. Three ALCYON cruises resulted in 5 400, 4 300, and 1 800 lb of yellowtail snapper. Silk snapper were found to be most abundant from 90 to 140 fm, black snapper from 40 to 80 fm, and blackfin snapper at intermediate depths. On one 12-day trip, using the ALCYON as a mothership from Alice Shoal west to the Honduran-Nicaraguan shelf, FAO personnel landed 23 000 lb principally jacks (Carangidae) and mutton and yellowtail snapper. Fish pot catches on Pedro Bank averaged 26 lb per lift, with groupers providing about one third of the catch.

Hispaniola-Puerto Rico (Zones 23 and 24). Very limited trawling by the OREGON in 100 - 200 fm around Hispaniola has resulted in light catches of queen snapper, silk snapper and wenchman (pink snapper). The principal trawl-caught foodfish around Puerto Rico was the Caribbean red snapper in 20 - 40 fm, but it was taken in small numbers. Handlines fished from 30 to 115 fm showed promising silk snapper potential along outer shelf depths north of the Virgin Islands from 75 to 100 fm, and blackfin snapper from 25 to 100 fm. Dominant groupers in the catch were red grouper in shallower depths and moustache grouper from 75 to 100 fm.

Handline explorations by the ALCYON on the north-east coast of Hispaniola and around the Virgin Islands have resulted in commercial catch rates. One trip took 21 000 lb of fish, including 10 000 lb of black snapper, 3 300 lb of blackfin snapper, and 2 700 lb of silk snapper. Fish pot explorations resulted in an average of 20 lb per lift, principally grouper, followed by blackfin snapper.

Lesser Antilles (Zones 25 and 26). A small number of trawl stations have been made on banks and slopes around the Lesser Antilles, with extremely poor results. Bottomline explorations have been more promising, however, yielding good catches of silk snapper from 35 to 90 fm along the edge of the bank north of Anguilla Island. Moderate catches of blackfin snapper were made in the same area. Handline catches off Dominica, St. Lucia, Grenada, and Tobago were very low, consisting primarily of yellowtail snapper, queen snapper, and miscellaneous serranids.

In summary, the area of greatest snapper and grouper fishery potential appears to be the vast shelf and bank complex off Honduras and Nicaragua. Inshore portions of the shelf should sustain a fishery somewhat more intense than that currently being carried out by local fishermen. Black and Nassau groupers, along with yellowtail snapper, provide the inshore potential, along with lane snapper. Offshore, the most prominent species is the silk snapper, taken in deeper water along the edge of the Continental Shelf and Banks. Next are the blackfin and Caribbean red snappers at lesser depths. These resources are undergoing initial exploitation, with the present catch providing only an indication of what could be developed.

The catch rates experienced by the most efficient handline operations probably can be increased through the use of fish trawls. Roller-rigged trawls would eliminate dependence on cyclic feeding behaviour and allow fishing where snappers are thinly scattered over a large area. Concentrations of snapper, especially silk snapper, have been recorded in mid-water off the Honduran-Nicaraguan shelf, and might prove susceptible to mid-water trawls.

Other Caribbean areas appear to offer less potential for trawling, with the possible exceptions of Venezuela and portions of Colombia. The bank and shelf areas around Jamaica, Hispaniola, and the Windward Islands have the potential required to expand their fisheries for snappers and groupers.

Rather crude extrapolations, based on catch rates by the OREGON, published data from other sources, and abundance estimates for selected areas, indicate a latent snapper and grouper resource for the Caribbean on the order of 41 000 t - many times the amount taken presently.

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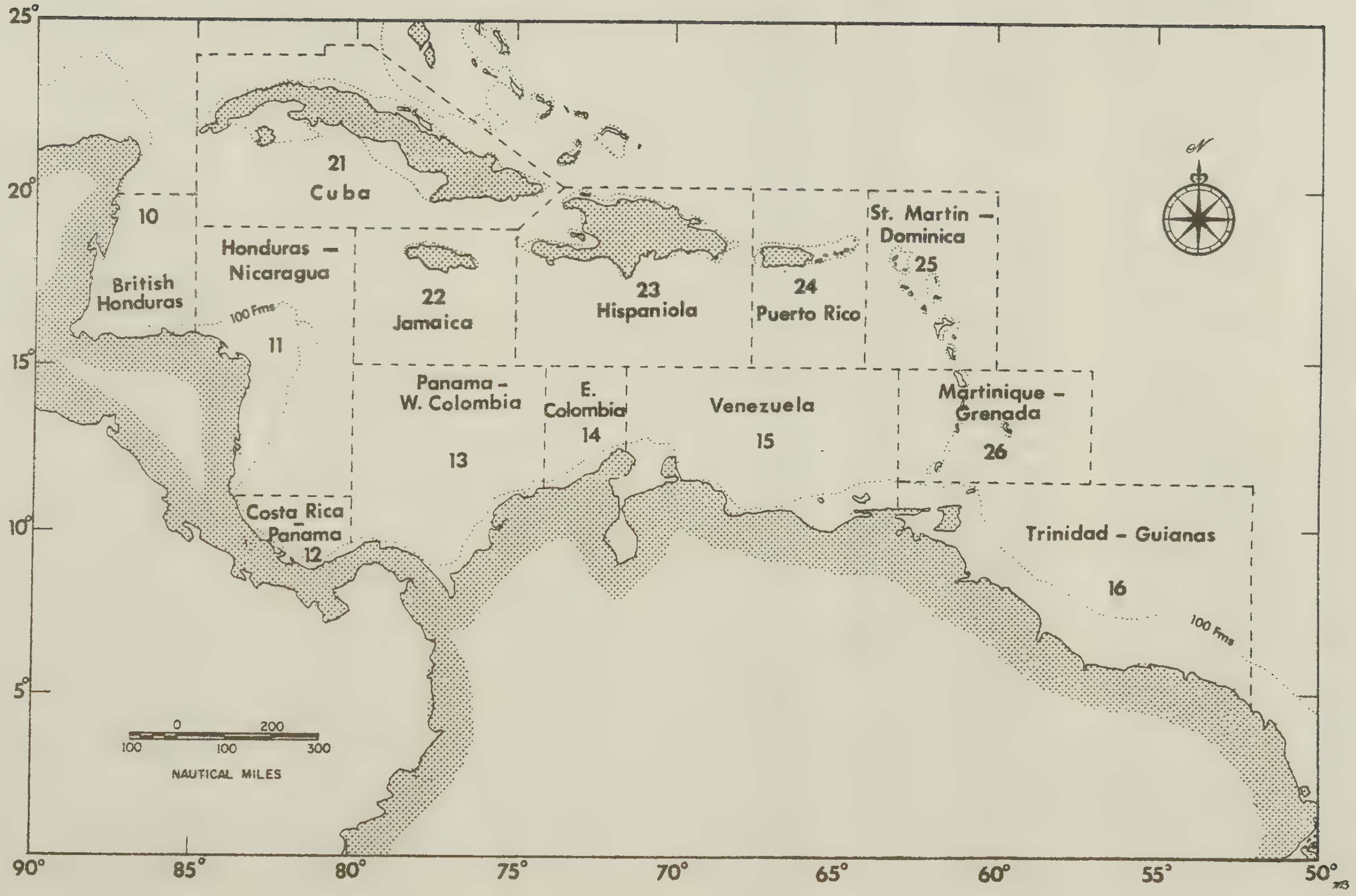
25°
20°
15°
10°
5°
90°
85°
80°
75°
70°
65°
60°
55°
50°
10
British Honduras
21
Cuba
Honduras – Nicaragua
100 Fms
11
22
Jamaica
23
Hispaniola
24
Puerto Rico
St. Martin – Dominica
25
Panama – W. Colombia
13
E. Colombia
14
Venezuela
15
Martinique – Grenada
26
Costa Rica – Panama
12
Trinidad – Guianas
16
100 Fms
0
200
100
100
300
NAUTICAL MILES

Fig. 1 Faunal zones recognized for the surveys on the R.V. OREGON in the Caribbean Sea

FOOD OF SKIPJACK TUNA IN THE CARIBBEAN SEA AND ADJACENT OCEANIC WATERS[1]

by

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1 INTRODUCTION

The principal function of the Tropical Atlantic Biological Laboratory (TABL) is the study of the ecology of commercially important species of tunas in the tropical Atlantic Ocean. This report presents the results of studies of the food and feeding habits of skipjack tuna (Katsuwonus pelamis) in the Caribbean Sea and adjacent oceanic waters.

Although numerous papers exist on the food of tunas in the Atlantic Ocean, only one (Suares and Duarte, 1961) has been published on the food of skipjack tuna in the Caribbean Sea. That study was based on 73 stomachs (68 with food) collected from commercial fishing grounds between Cayo Diego (south of Cienaga de Zapata) and Punta Tabaco (northwest of Piñar del Rio), Cuba. Their food consisted of fish (74 percent by volume), squid (23 percent), and crustaceans (2 percent). The most abundant forage organisms were Ommastrephes pteropus, larvae of Synodus sp. and Acanthurus spp., Balistidae, Holocentridae, Serranidae, Clinidae, and megalopae and larvae of stomatopods. In about 90 percent of the stomachs, the volume of individual organisms did not displace more than 0.5 ml. No differences were observed between the feeding habits in the morning and afternoon.

2 SAMPLING PROCEDURES AND MEASUREMENTS

Skipjack tuna stomachs were collected by Bureau of Commercial Fisheries personnel in the Caribbean Sea and adjacent oceanic waters (Figure 1.) during UNDAUNTED cruise 2 (February and March 1965) and GERONIMO cruises 6 (October, November, December 1965) and 7 (February and March 1966). Of 369 skipjack tuna stomachs examined, 347 (94 percent) contained food. Tuna varied from 38 to 82 cm in fork length (most were between 45 and 60 cm). Method of capture and number of stomachs collected each month are shown in Table I.

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[1] Contribution No. 90, Bureau of Commercial Fisheries Tropical Atlantic Biological Laboratory, Miami, Florida 33149

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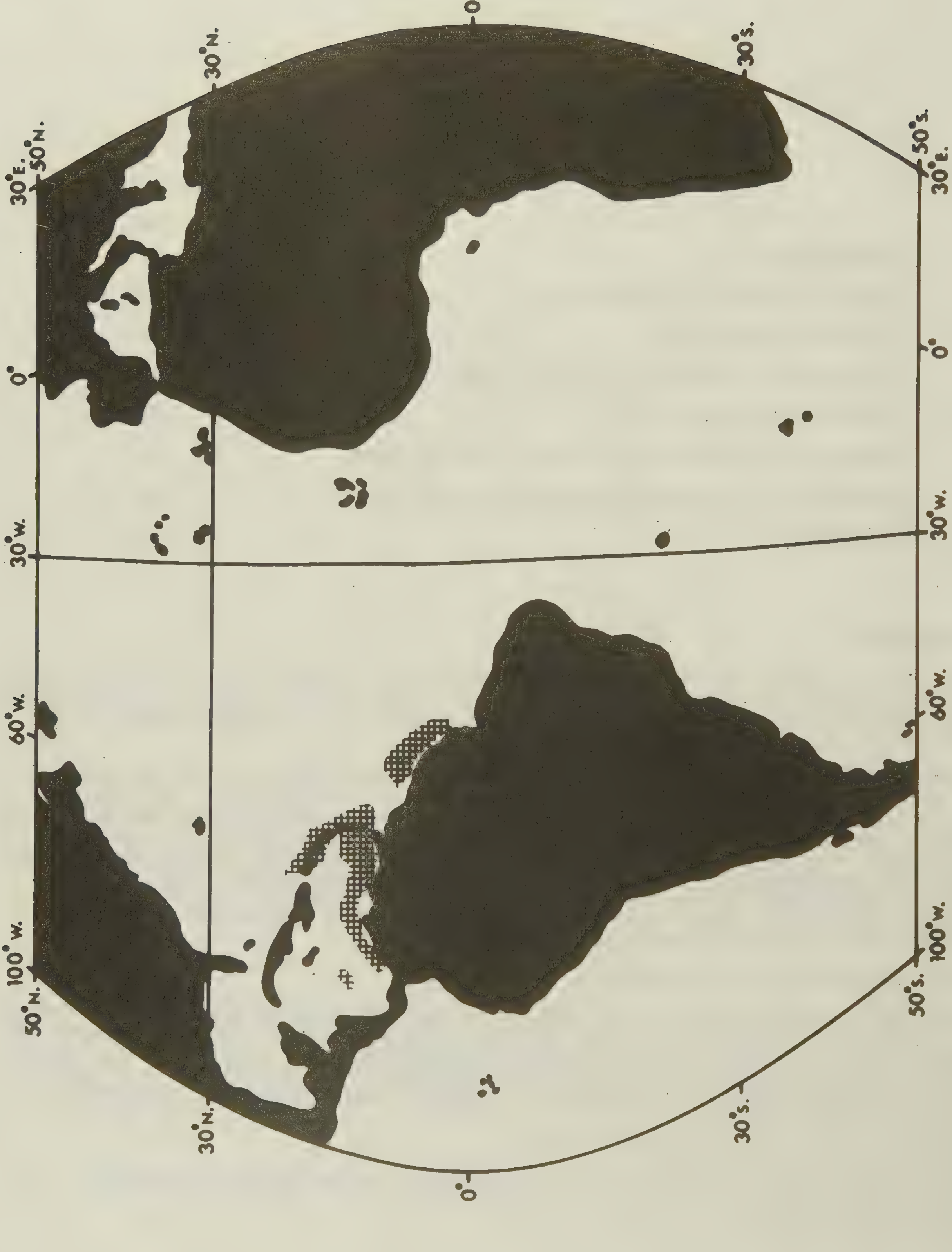
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Fig. 1 Crosshatching shows areas where skipjack tuna stomachs were collected

TABLE I

Skipjack tuna stomachs collected in the Caribbean Sea and adjacent oceanic waters showing months and methods of capture

Ship	Cruise	Month	Method of capture	Number of stomachs
GERONIMO	6	Aug. 1965	Trolling	8
GERONIMO	6	Sept. 1965	Trolling	1
GERONIMO	6	Oct. 1965	Trolling	6
GERONIMO	7	April 1966	Live bait	149
GERONIMO	7	Feb. 1966	Trolling	14
GERONIMO	7	March 1966	Trolling	7
UNDAUNTED	2	Feb. 1965	Trolling	3
UNDAUNTED	2	March 1965	Live bait	103
UNDAUNTED	2	March 1965	Trolling	1
UNDAUNTED	2	April 1965	Live bait	77
				Total 369

Most of the stomachs were removed from the fish shortly after capture and placed in polyethylene bags containing 10 percent formalin. Each stomach was pierced in several places to ensure rapid penetration of formalin. Before examination, the stomachs were soaked in fresh water for 24 hours to remove excess formalin. The organisms in the stomachs were then sorted into broad taxonomic categories and later identified as closely as possible. All identified taxa were counted and their volumes were determined by the displacement of water in a graduated cylinder. Morphometric measurements were made of some of the food organisms.

The data were analysed quantitatively by the volumetric and percentage of occurrence methods.

3 COMPOSITION OF TUNA FOOD

The food of skipjack tuna consisted of fishes, molluscs, and crustaceans (Figure 2; Tables II, III, and IV). Numerically and volumetrically, fishes were the most important food, molluscs were second, and crustaceans third. The mean volumes of most taxa were within a range of 0.1 to 1.0 ml (Figure 3). Total volumes of the stomach contents of individual skipjack tuna varied from less than 0.1 to 95.0 ml; 85 percent were below 30.0 ml. Of the fishes in the stomachs, 34 kinds were identified to species, 27 to genus, 21 to family, and 5 to higher categories. Six kinds of molluscs were identified to species, one to genus, two to family, and four to higher categories. Of the crustaceans, one was identified to species, one to family, and seven to higher categories. (Figure 4).

The most frequently found taxa of fishes, in descending order, were Scombridae, *Auxis* spp., *Paranthias furcifer*, Mullidae, *Dactylopterus volitans*, *Holocentrus* spp., *Holocanthus* spp., *Acanthurus* spp., Gempylidae, *Gempylus serpens*, Monacanthidae, *Chaetodon* spp., *Vomer setapinnis*, *Cubiceps* spp., *Cantherines* spp., *Pseudupeneus maculatus*, and *Acanthurus coeruleus*. Most of these fish ranked high in volume also. Although many fishes ranked low in frequency of occurrence, a great number of them were relatively important because of their large mean volume (Table II). Most of the fishes were juvenile and larval pelagic forms, of oceanic distribution.

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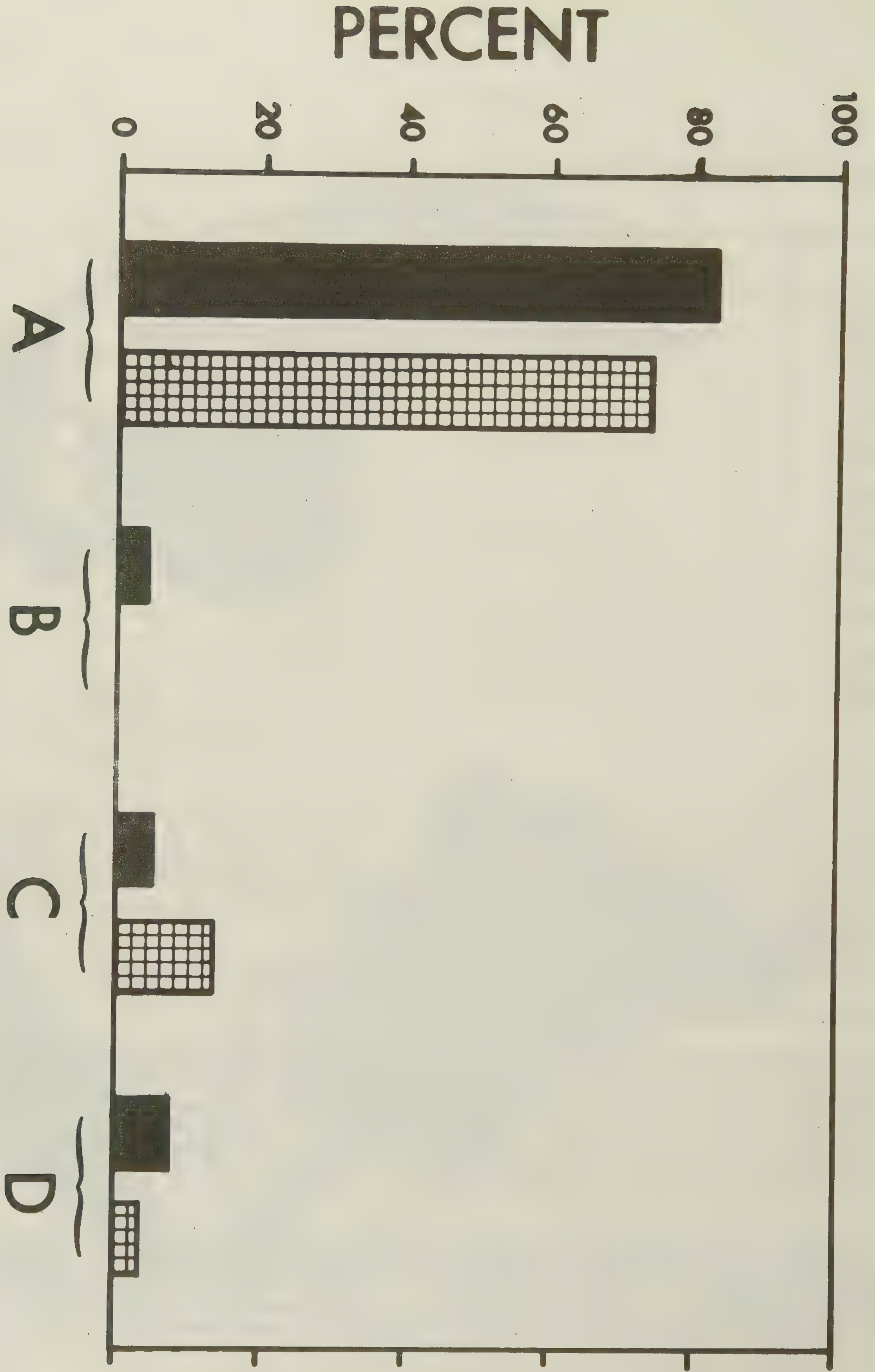

Fig. 2 Percentage of total food contributed by the four major categories of food in stomachs of skipjack tuna captured in the Caribbean Sea and adjacent Atlantic Ocean. Solid columns represent the number of organisms and checked columns represent volumes. A = fishes; B = Crustacea; C = Cephalopoda; D = other molluscs

4.8

TABLE II

Check list of forage fish (arranged in order of frequency of occurrence) found in 347 skipjack tuna stomachs that contained food, collected from the Caribbean Sea and adjacent Atlantic Ocean, 1965-66 (frequency of occurrence, total volume, percentage of total volume of all food, and mean volume are given for each taxon)

Taxon	Frequency of occurrence		Volume		Mean Volume (ml)
	Number	Percentage	Total (ml)	Percentage of total	
Unidentifiable	241	69.2	895.9	16.9	.5
Scombridae	89	25.5	269.9	5.1	1.2
Auxis spp.	85	24.4	680.8	12.9	2.3
Paranthias furcifer	75	21.5	440.1	8.3	1.1
Mullidae	67	19.2	390.7	7.4	1.2
Dactytopterus volitans	66	18.9	110.9	2.1	.2
Holocentrus spp.	61	17.5	58.5	1.1	.5
Holocanthus spp.	58	16.6	50.2	.9	.4
Acanthurus spp.	55	15.8	71.7	1.4	.7
Gempylidae	52	14.9	72.1	1.4	.6
Gempylus serpens	40	11.4	103.2	1.9	.8
Monocanthidae	39	11.2	35.7	.7	.5
Chaetodon spp.	30	8.6	18.4	.3	.4
Vomer setapinnis	22	6.3	26.1	.5	.8
Cubiceps spp.	20	5.7	128.0	2.4	1.9
Cantherines sp.	20	5.7	34.6	.6	1.2
Pseudupeneus maculatus	19	5.4	174.2	3.3	1.1
Acanthurus coeruleus	18	5.1	21.6	.4	.7
Balistes spp.	17	4.8	78.8	1.5	1.7
Carangidae	16	4.5	105.9	2.0	1.9
Monocanthus spp.	13	3.7	5.8	.1	.4
Syngnathus spp.	10	2.8	1.0	> .1	.9
Scorpaena spp.	10	2.8	1.8	> .1	.2
Katsuwonus pelamis	10	2.8	86.0	1.6	5.0
Balistidae	10	2.8	9.1	.2	.8
Lactophrys spp.	10	2.8	2.3	> .1	.2
Priacanthidae	9	2.5	9.1	.2	.5
Tetradontidae	9	2.5	6.5	.1	.6
Sphoeroides spp.	8	2.2	6.3	.1	.5
Exocoetidae	7	2.0	64.1	1.2	12.3
Congridae	7	2.0	2.2	> .1	.3
Percoidei	7	2.0	7.1	> .1	.5
Priacanthus spp.	6	1.7	9.6	> .1	1.1
Scorpaenidae	5	1.4	.6	> .1	.2
Caranx spp.	5	1.4			
Decapterus punctatus	5	1.4	31.1	.6	3.9
Lagocephalus spp.	5	1.4	7.4	.1	1.5
Holocentrus vexillarius	4	1.1	2.2	> .1	.5
Serranidae	4	1.1	2.0	> .1	.1
Pseudopriacanthus altus	4	1.1	4.7	.1	.6

4.8

TABLE II continued

Taxon	Frequency of occurrence		Volume		Mean Volume (ml)
	Number	Percentage	Total (ml)	Percentage of total	
Decapterus spp.	4	1.1	12.5	.2	2.5
Collybus drachme	4	1.1	2.5	> .1	.4
Scombroidei	4	1.1	4.9	.1	1.2
Balistes vetula	4	1.1	76.5	1.4	2.3
Anguilloidei	3	.8	.3	> .1	.1
Holocentridae	3	.8	.6	> .1	.2
Caranx bartholomaei	3	.8	3.4	> .1	1.1
Thunnus spp.	3	.8	9.6	.2	3.2
Stromateidae	3	.8	8.6	.2	1.4
Ranzania laevis	3	.8	9.2	.2	3.1
Hippocampus erectus	2	.5	.7	> .1	.4
Syngnathus floridae	2	.5	.3	> .1	.1
Priacanthus cruenatus	2	.5	2.2	> .1	1.1
Selar crumenopthalmus	2	.5	3.0	> .1	.1
Trachinotus spp.	2	.5	.8	> .1	.4
Holocanthus ciliaris	2	.5	.7	> .1	.2
Holocanthus tricolor	2	.5	.5	> .1	.2
Nesiarchus nasutus	2	.5	11.7	.2	2.9
Ophichthidae	1	.3	.6	> .1	
Paralepididae	1	.3	.8	> .1	.2
Exocoetus obtusirostris	1	.3	50.0	.9	50.0
Hirundichthys sp.	1	.3	.9	> .1	.5
Syngnathidae	1	.3	.1	> .1	.1
Hippocampus spp.	1	.3	.1	> .1	
Myripristis jacobus	1	.3	3.0	> .1	3.0
Antigonia capros	1	.3	.6	> .1	.6
Polynemidae	1	.3	16.5	.3	
Paranthais sp.	1	.3	.2	> .1	.2
Priacanthus arenatus	1	.3	1.0	> .1	1.0
Malacanthus plumieri	1	.3	1.5	> .1	1.5
Selar sp.	1	.3	4.0	> .1	
Coryphaena spp.	1	.3	1.5	> .1	1.5
Pseudupeneus spp.	1	.3	8.8	.2	2.6
Chaetodon sedenitarius	1	.3	.1	> .1	.1
Acanthurus bahianus	1	.3	2.2	> .1	.7
Gempylus sp.	1	.3	.9	> .1	.1
Euthynnus alletteratus	1	.3	.3	> .1	.3
Thunnus atlanticus	1	.3	2.0	> .1	2.0
Cubiceps gracilis	1	.3	1.3	> .1	1.3
Balistoidei	1	.3	.3	> .1	.2
Xanthichthys ringens	1	.3	3.0	> .1	1.5
Lagocephalus pachycephalus	1	.3	2.2	> .1	2.2
Diodontidae	1	.3	.2	> .1	.2
Chiasmodontidae	1	.3	.6	> .1	.6
Cantherines pullus	1	.3	9.0	.2	3.0
Alutera spp.	1	.3	.2	> .1	.3
Molidae	1	.3	.6	> .1	.3

TABLE III

Check list of forage molluscs (arranged in order of frequency of occurrence) found in 347 skipjack tuna stomachs that contained food, collected from the Caribbean Sea and adjacent Atlantic Ocean, 1965-66 (frequency of occurrence, total volume, percentage of total volume of all food, and mean volume are given for each taxon)

Taxon	Frequency of occurrence		Volume		Mean Volume (ml)
	Number	Percentage	Total (ml)	Percentage of total	
Ommastrephidae	63	18.1	439.1	8.3	2.2
Cephalopoda	33	9.4	205.7	3.9	.9
Illex illecebrosus	28	8.0	321.6	6.1	3.6
Cavolinia unicinata	8	2.2	1.0	> .1	.1
Oxygyrus keraudreni	6	1.7	.6	.1	.1
Teuthoidea (General)	4	1.1	5.6	> .1	.1
Octopoda (General)	2	.5	.3	> .1	.2
Mesogastropoda (Atlantacaea)	1	.3	.1	> .1	.1
Tonnidae	1	.3	.1	> .1	.1
Tonna galea	1	.3	.1	> .1	.1
Diacria spinosa	1	.3	.1	> .1	.1
Ommastrephes spp.	1	.3	8.0	.2	2.6
Tremoctopus violaceus	1	.3	.5	> .1	.5

TABLE IV

Check list of forage crustaceans (arranged in order of frequency of occurrence) found in 347 skipjack tuna stomachs that contained food, collected from the Caribbean Sea and adjacent Atlantic Ocean, 1965-66 (frequency of occurrence, total volume, percentage of total volume of all food, and mean volume are given for each taxon)

Taxon	Frequency of occurrence		Volume		Mean Volume (ml)
	Number	Percentage	Total (ml)	Percentage of total	
Decapoda (Brachyura)	30	8.6	3.6	.1	.1
Stomatopoda	27	7.7	11.4	.2	.5
Raninnidae	22	6.3	3.4	.1	.1
Crustacea (not further identified)	17	4.8	2.2		
Amphipoda (Hyperiidae)	4	1.1	.4	> .1	.1
Decapoda (Macrura-Natantia-caridean shrimp larvae)	2	.5	1.1	> .1	.1
Isopoda	2	.5	.2	> .1	.1
Phronima sedentaria	1	.3	.2	> .1	.2
Decapoda (Macrura-Reptantia-phyllosoma larvae)	1	.3	.1	> .1	.1

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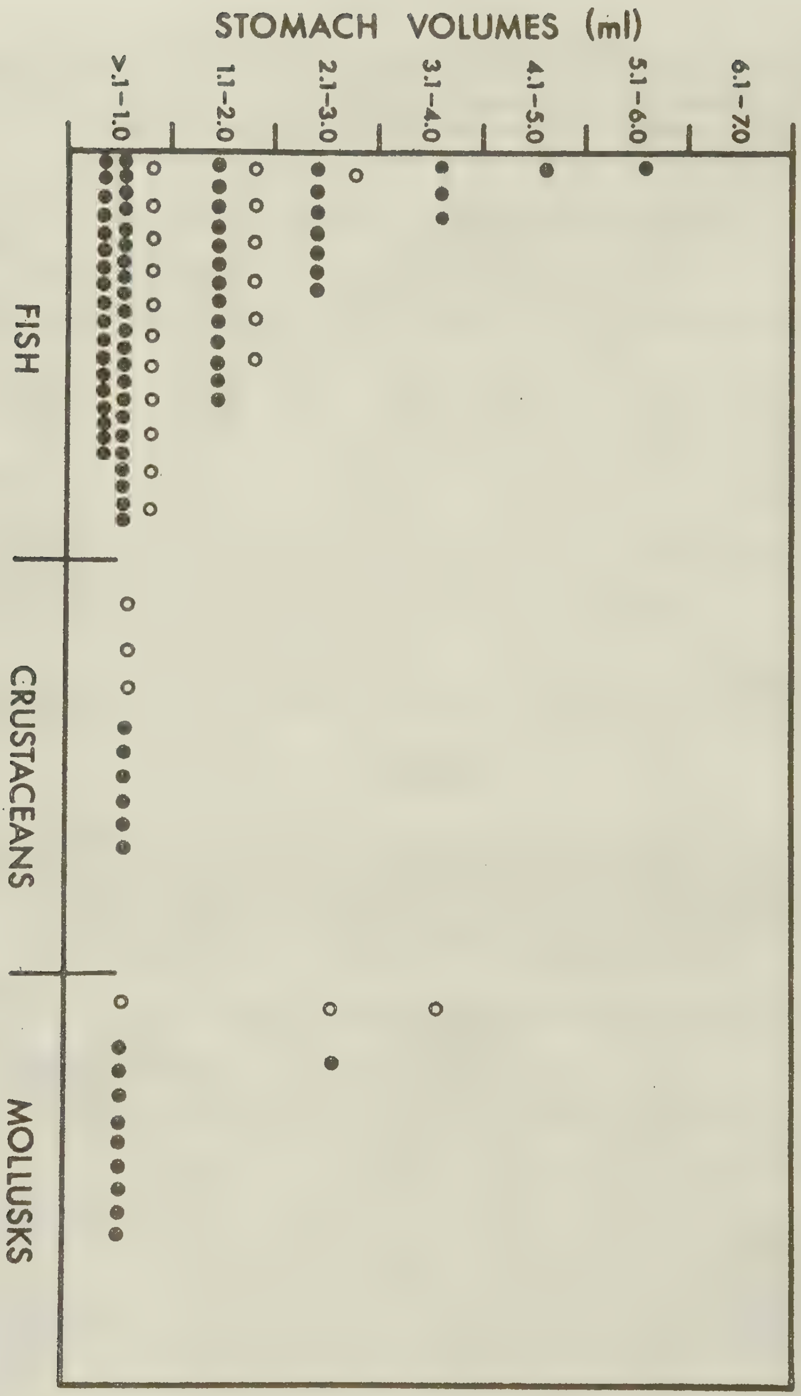

Fig. 3 The distribution of the mean displacement volumes of individual taxa found in the stomachs of skipjack tuna from the Caribbean Sea and adjacent Atlantic Ocean

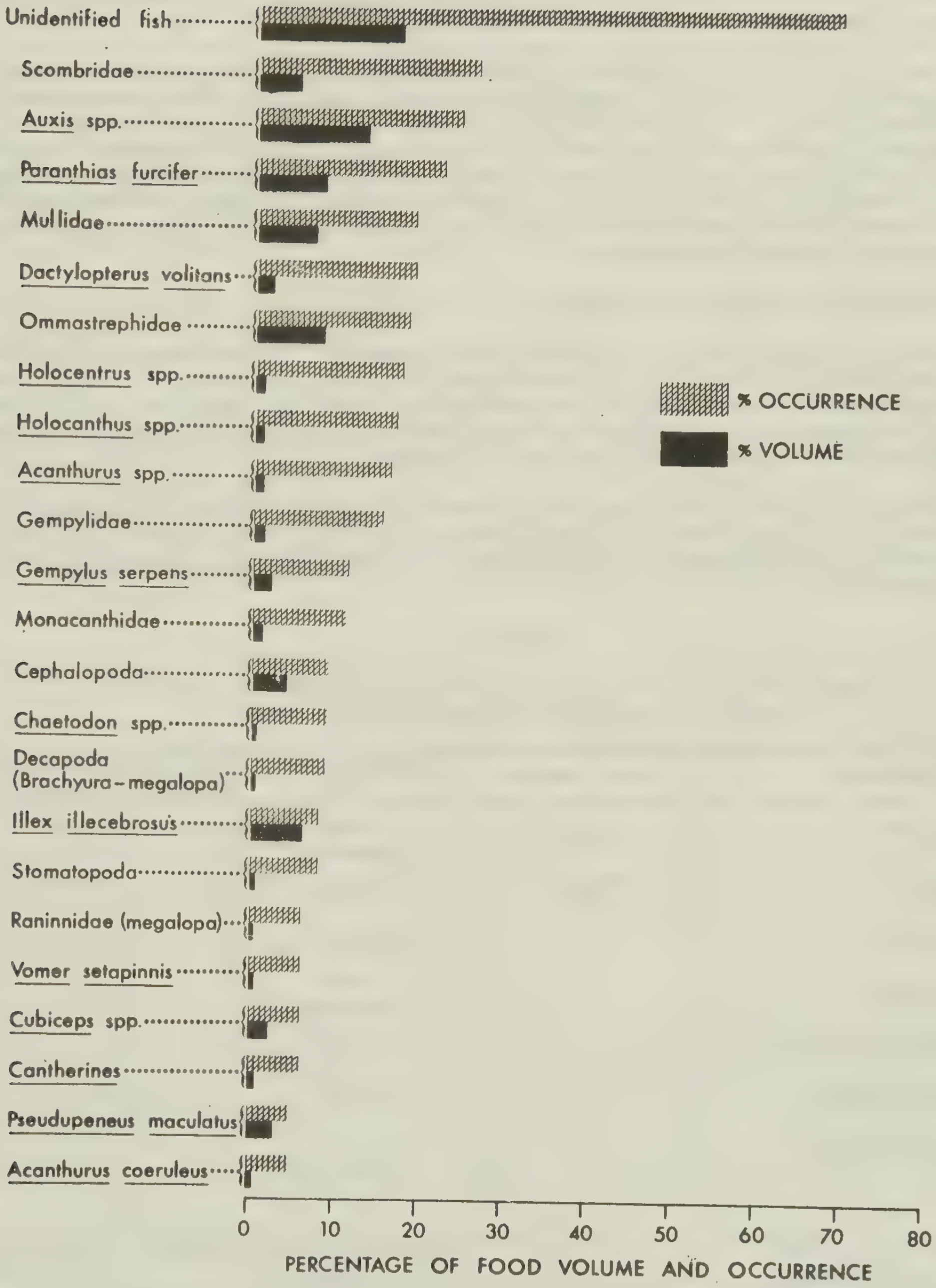

Fig. 4 Relative importance of principal food items in the diet of skipjack tuna from the Caribbean Sea and adjacent oceanic waters

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Molluscs consisted of cephalopods, several species of heteropods, pteropods, and larval Tonnidae. Since the external identifying characters of cephalopods are first to be destroyed by digestive processes, only a small number of cephalopods could be identified to species. Most were identified to family or class. In terms of volume, cephalopods were more important than other molluscs. The highest average displacement volume (2.6 ml) was recorded for *Ommastrephes* spp. The remaining molluscan components had an average displacement volume of less than 1.0 ml.

Crustaceans were chiefly megalopal forms, listed as Decapoda (Brachyura) and Raninnidae, various forms of larval stomatopods, unidentified crustaceans, hyperiid amphipods, caridean shrimp larvae, isopods, and phyllosoma larvae. The fact that skipjack tuna feed on the almost transparent phyllosoma and stomatopod larvae implies that the fish are able to detect the larvae by sight or by some other mechanism. The relatively large numbers of these forms found in stomachs of skipjack tuna in the present study and in others (Reintjes and King, 1953; King and Ikehara, 1956; and Nakamura, 1965) indicate that these larvae are not ingested by accident. The volume of the crustacean group was small; crustaceans were volumetrically insignificant.

4 SCOMBRIDAE AS FORAGE FOR *KATSUWONUS PELAMIS*

Because tunas are scombrid fishes, the presence of scombrids in the stomachs of skipjack tunas deserves special consideration. The scombrids were identified from vertebrae; all were juveniles. Scombridae (not further identified) were in 25 percent of the stomachs, *Auxis* spp. in 23 percent, *Katsuwonus pelamis* in 4 percent, and *Thunnus* spp. in 1 percent. Specimens of *Euthynnus alletteratus*, *Thunnus atlanticus*, and Scombridei made up less than 1 percent.

The total number of measurable specimens of scombrids, their fork lengths, and the number of specimens per stomach are given in Table V. Only Scombridae and *Auxis* spp. were relatively numerous. Numbers of *Thunnus* spp., *Auxis thazard*, *E. alletteratus*, *K. pelamis*, and *T. atlanticus* were low - one to three per tuna stomach.

TABLE V

Juvenile scombrids found in stomachs of skipjack tuna from the Caribbean Sea and the adjacent Atlantic Ocean

Specimens	Total number	Length range (mm)	No. of specimens in a single stomach
Scombridae	175	not measured	1-15
Auxis spp.	264	23-91	1-13
Thunnus spp.	4	64-72	1-2
Auxis thazard	5	not measured	1-3
Euthynnus alletteratus	1	40	1
Katsuwonus pelamis	14	46-94	1-2
Thunnus atlanticus	1	59	1

Tuna as forage for other tunas has been reported in many studies: Suarez and Duarte (1961) observed juvenile *T. atlanticus* (5 - 150 mm fork length) and *K. pelamis* (35 - 145 mm fork length) in stomachs of skipjack tunas; Nakamura (1965) reported a high frequency of occurrence (24.8 - 44.8 percent) of juvenile tunas in the stomachs of skipjack tunas; King and Ikehara (1956) found juvenile skipjack in the stomachs of yellowfin (*T. albacares*) and bigeye (*T. obesus*) tunas; and Reintjes and King (1953) found skipjack tuna in 1.5 percent of the stomachs of yellowfin tuna, and 3.9 percent of the yellowfin tuna stomachs contained other species of tunas; and juvenile tuna in the stomachs of other tunas were also reported by Koga (1958 a, b) and Alverson (1963).

5 TEMPORAL VARIATION OF FOOD

The data of the present study did not permit analysis of seasonal or monthly variations, but it was possible to examine diurnal variation in stomach contents by arranging all the data in terms of hour of the day (Figure 5).

The percentage of empty stomachs appeared highest, and the mean stomach volume was lowest, near midday. A chi-square test of heterogeneity indicated that the observed difference in the percentage of empty stomachs near midday was significant ($P < 0.005$).

The diurnal fluctuation in feeding during our survey was similar to that observed by other investigators (Talbot and Penrith, 1963; Nakamura, 1965; Sokolov, 1967). Nakamura (1965) suggested that the diurnal feeding pattern of skipjack tuna was based on availability of food (movement of zooplankton and forage organisms, during the midday period of maximum illumination, to depths beyond those occupied by the surface-dwelling skipjack tuna) or to satiation of tuna after the morning feeding period.

6 COMPARISON OF FINDINGS IN THE PRESENT STUDY WITH OTHERS

Although the food of skipjack tuna in different areas is generally similar, differences between certain areas can be pronounced in some features (Nakamura, 1961; Alverson, 1963). Suarez and Duarte (1961) found fewer taxa in the stomachs of skipjack tuna in Cuban waters (62) than were found in the present study. The taxonomic similarity of forage organisms between the two studies was weak, particularly for molluscs and fishes; the molluscs and fishes in Suarez and Bello's study consisted primarily of shallow-water forms whereas those in the present study were primarily oceanic. The difference was greatest between the two studies in the species of fishes consumed by skipjack tuna, which may be explained by the fact that most of the Suarez and Bello's collections were made in shallow coastal waters and ours were in the oceanic environment. The implication probably is that skipjack tuna are opportunistic feeders and that the dissimilarity in diet reflects a difference in availability of food rather than in preference.

Evidence in the literature further supports the view that skipjack tunas change their diet as they move from one location to another (Alverson, 1963; Nakamura, 1965). For example, in the eastern Pacific euphausids were the most numerous food item (Alverson, 1963); in the waters from Marquesas and Tuamotu Islands stomatopods predominated (Nakamura, 1965); and stomatopods also were a prominent food item in the diet of skipjack tuna off West Africa (unpublished data of the Tropical Atlantic Biological Laboratory). In the present study, however, fishes were far more numerous than crustaceans.

The differences in taxonomic composition of forage organisms consumed by skipjack tuna of various sizes were not obvious in the present study as they were in some others. Nakamura (1965), for instance, noted that small skipjack tuna ate more crustaceans than did the larger ones. Yuen (1959) found that larger skipjack tuna depended more on fish than on molluscs and crustaceans.

7 COMPETITION FOR FOOD BETWEEN SKIPJACK AND OTHER TUNAS

I compared food of skipjack tuna with that of yellowfin tuna (unpublished data from Tropical Atlantic Biological Laboratory files) from the same area and found a decided similarity in forage species of skipjack and yellowfin tunas - about 50 percent of the forage taxa were common to both species. Despite the wide variety of forage fishes available to the two tuna species, only a few species appeared important as food organisms for both. In terms of frequency of occurrence, number, and volume, the following forms were common to skipjack and yellowfin tunas: Scombridae, *Paranthias furcifer*, *Auxis* spp., Molidae, *Dactilopterus volitans*, and *Holocanthus* spp. Some of these taxa were represented by the hundreds in the stomachs of yellowfin tunas. Among crustaceans, stomatopods were common to the two species. Although megalopal stages appeared regularly in stomachs of both, megalopal stages of Raninnidae were identified from skipjack tuna stomachs only. Molluscs eaten by both consisted chiefly of cephalopods, mainly squid.

This evidence supports the opinion that skipjack tuna and yellowfin tuna compete for food in the Caribbean Sea.

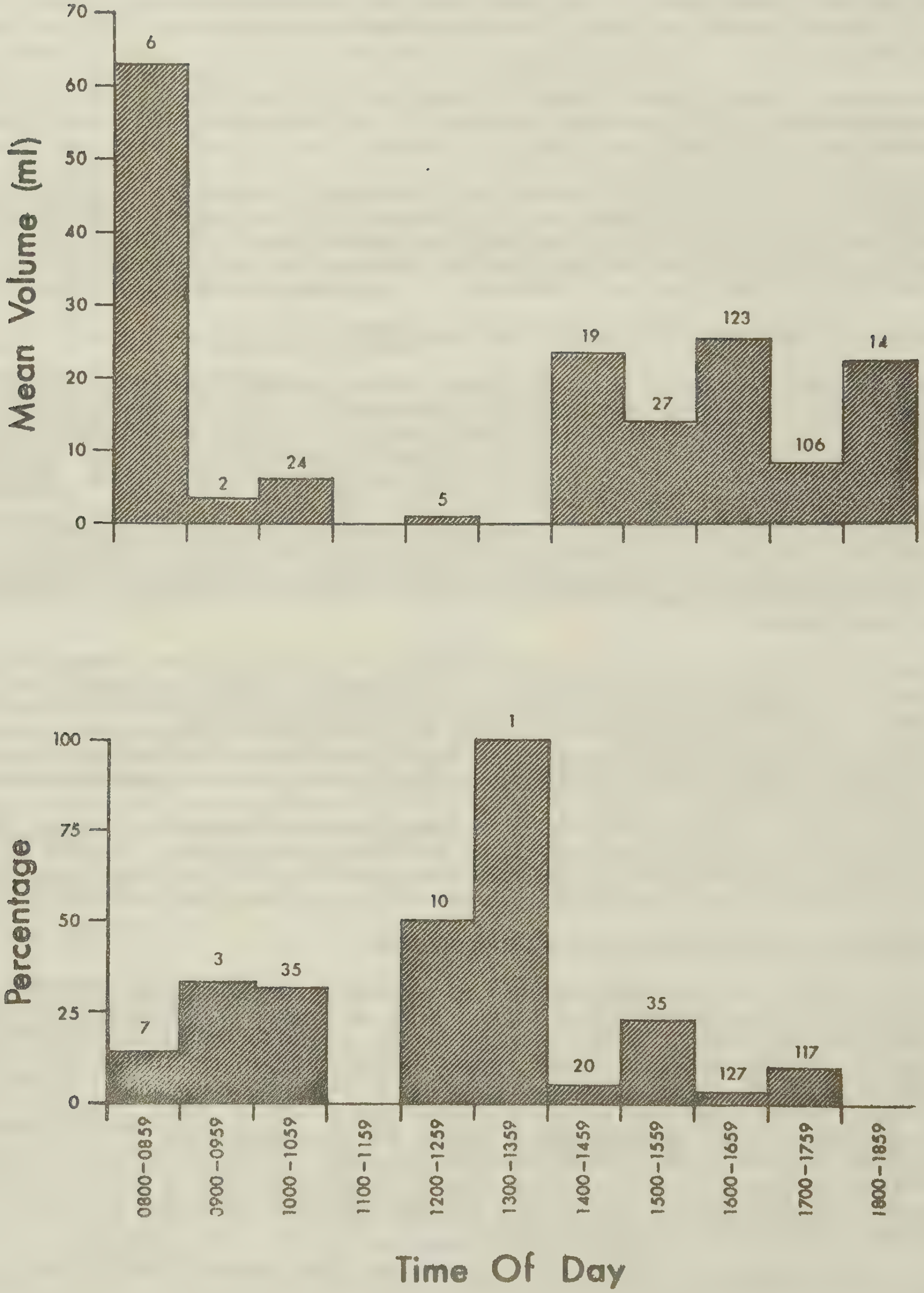

Fig. 5 Distribution of mean stomach volumes and percentage of empty stomachs of skipjack tuna from the Caribbean Sea and adjacent oceanic waters. The number above each column indicates the number of stomachs examined

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Table IV	Check list of forage crustaceans (arranged in order of frequency of occurrence) found in 347 skipjack tuna stomachs that contained food, collected from the Caribbean Sea and adjacent Atlantic Ocean, 1965-66 (frequency of occurrence, total volume, percentage of total volume of all food, and mean volume are given for each taxon)
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Figure 1	Crosshatching shows areas where skipjack tuna stomachs were collected
Figure 2	Percentage of total food contributed by the four major categories of food in stomachs of skipjack tuna captured in the Caribbean Sea and adjacent Atlantic Ocean. Solid columns represent the number of organisms and checked columns represent volumes. A=fishes; B=Crustacea; C=Cephalopoda: D=other molluscs
Figure 3	The distribution of the mean displacement volumes of individual taxa found in the stomachs of skipjack tuna from the Carribean Sea and adjacent Atlantic Ocean
Figure 4	Relative importance of principal food items in the diet of skipjack tuna from the Caribbean Sea and adjacent oceanic waters
Figure 5	Distribution of mean stomach volumes and percentage of empty stomachs of skipjack tuna from the Caribbean Sea and adjacent oceanic waters. The number above each column indicates the number of stomachs examined

AERIAL REMOTE SENSING RECONNAISSANCE OF SURFACE SCHOOLING FISH

by

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1 INTRODUCTION

The National Aeronautics and Space Administration (NASA) has undertaken an extensive study to determine the feasibility of developing a satellite system to survey the resources of the earth. The studies now being conducted will determine the feasibility of utilizing remote sensors aboard both aircraft and spacecraft to assess aspects of our aquatic, mineral, forestry, water, agricultural, and other resources. These sensors operate on the principle that each object on earth reflects, absorbs, or re-emits energy (electromagnetic radiation) in a manner characteristic of the object's physical and molecular structure giving each its own spectral signature. One group of sensors, multispectral cameras, record the spatial distribution of electromagnetic radiation from the target over some narrow portion of the spectrum. Other sensors, e.g., scanning spectrometers, measure the intensity and spatial distribution of the radiation as a function of wavelength over the entire spectrum from the ultra-violet through the visible into the non-visible infra-red and micro-wave regions.

The problem now exists of applying this new technology, much of which was developed for space research, to such earth-bound applications as fishery resource assessment, a problem of primary concern to the Bureau of Commercial Fisheries. To achieve this objective the Exploratory Fishing and Gear Research Base, Pascagoula, Mississippi, initiated an Aerial Fishery Survey Program in 1966 directed toward the application of remote sensing technology to the problem of pelagic fishery resource assessment, i.e., the location, identification, and quantification of surface and near-surface fish stocks. Because of complexities of the problem and the inherent limitations of each method considered, a number of approaches are being taken.

2 AERIAL PHOTOGRAMMETRIC STUDIES

Our initial effort in this Program was to determine the feasibility of utilizing aerial photography in conjunction with "ground truth" observations as a means of obtaining quantitative and qualitative data on pelagic fish stocks. More than 1 000 schools have been photographed using black and white, colour, and colour infra-red films with various filter combinations. Sixty-five of these schools were sampled to determine size and species composition. Simultaneous sonar soundings were also obtained of a number of schools in an effort to determine sub-surface school configuration and density. Results have shown that the position and surface configuration of fish schools may be obtained in precise terms from high-altitude photography. Selected photographs are being subjected to colour separation and isodensitometric analyses to determine relationships which may exist between colour, film density, species, and school size respectively.

4.41

3 MULTISPECTRAL PHOTOGRAPHIC STUDIES

The aerial photogrammetric studies were limited in certain respects due to the problems of water penetration and the very subtle colour differences associated with some schools. Multispectral photographic techniques may be used, however, to detect these subtle differences and provide greater depth penetration by excluding those spectral regions which contribute little or nothing to the information content of the photography. Black and white as well as colour films are inherently sensitive to large portions of the electromagnetic spectrum. In the case of fish schools in their natural environment, the colour differences which may be used to locate and identify certain species may very easily be lost in the background reflectivity of the scene and hence pass undetected upon examination of the photographs. Multispectral photography separates the reflected radiation into a number of wavelength bands which have been pre-selected to yield maximum differentiation between the target and background. This is accomplished by using narrow band filters which cover only the area of spectral difference and thus enhance or provide greater contrast between the target and background. A series of multispectral experiments were conducted by the Long Island University Science and Engineering Research Group under contract to the Bureau of Commercial Fisheries, Pascagoula, during June and August 1968 to determine the feasibility of using these techniques to locate and identify surface and near-surface fish schools. In the initial stages of the experiment, the wavelengths of greatest depth penetration were determined for two regions along the Northern Gulf coast. Special narrow band filters were then obtained to look at those parts of the spectrum which would give the greatest depth penetration in these waters. A series of test flights were then made over these areas using a four-lens multispectral camera system and high-speed emulsions. The University's 15 x 120 ft target arrays, which consisted of red, blue, green, yellow, and grey scale panels, were placed in the scene. One array was submerged at a depth of 40 ft while a second array was placed on the surface. These targets served to evaluate the performance of the sensor for underwater penetration and as a control in the analysis of the photographic imagery. Schools photographed during these experiments were sampled to provide "ground truth" data on size and species composition. In the analysis of the photography, an effort will be made to chromatically separate the background scene from the fish schools by the use of false colour presentations thus providing a means for detection and possible identification of pelagic fish stocks. Colorimetric and densitometric data will also be obtained from the colour ektachrome and camouflage detection films used. It is expected that these studies will contribute to an evaluation of multispectral photography as a means for locating and identifying fish schools.

4 SPECTRAL REFLECTANCE MEASUREMENTS

Many pelagic species may be identified on the basis of colour or distinctive patterns, e.g., the brownish colour of menhaden schools which is identifiable from visual observation. These characteristics are commonly used by commercial aircraft spotters in fishing operations to locate catchable schools. The use of these colour or spectral differences by the commercial fish spotter to identify species, suggests that spectral analyses of the reflected radiation may reveal characteristic spectral signatures which may be used to locate and identify fish schools in their natural environment under certain conditions. During September 1968 the Pascagoula Laboratory and TRW Systems obtained spectral reflectance measurements of 15 schooling species in the northern Gulf of Mexico; these included skipjack, *Elops saurus*; threadherring, *Opisthonema oglinum*; Spanish sardine, *Sardinella aurita*; Spanish mackerel, *Scomberomorus maculatus*; and other commercially important species. Measurements were made on single fish, fish in small groups and fish in schools inside impoundments, using a recently developed TRW spectrometer. The spectral reflectance curves (i.e., measurements of the intensity of the reflected light versus wavelength) were obtained under natural lighting conditions from both surface vessels and a stationary oceanographic platform. The spectral data obtained from these studies are being analysed by TRW in an effort to determine the spectral characteristics which will enable us to distinguish a school from the background radiation and differentiate between species. Preliminary analysis suggests that there are spectral differences of sufficient magnitude which would permit the location and identification of certain species in their natural environment from airborne observations. Final analysis of the data is expected to be completed within the next 30 days.

5 BIOLUMINESCENCE STUDIES

Another approach to the problem of locating and identifying pelagic fish stocks, which appears to have great potential, is the use of low-level light sensors, such as image intensifiers to detect the bioluminescence, or "fire" as it is referred to by fishermen, associated with most schools. The Spanish mackerel fishery, which yields an annual catch of four to six million lb, serves to illustrate the potential of this method. In Florida this fishery is carried on, chiefly with gill nets and haul seines at night. The fish are sighted by the "fire" in the water. This "fire" is a result of the movement of fish schools which cause luminescent organisms in the water to glow momentarily. Rapidly swimming fish cause these organisms to luminesce, thus outlining their bodies with light and leaving trails of "fire". Large schools of mackerel containing five to ten t are identified by individual flashes within a glowing sphere of bioluminescence. The "fire" can be seen best with the naked eye on moonless nights; however, fishing is also done on cloudy nights.

During the past three months a series of tests have been conducted by the Pascagoula Laboratory using an image intensifier on loan from the Night Vision Laboratories, Fort Belvoir, Virginia. The intensifier used in these studies amplifies the ambient light or, in the case of bioluminescence, the emitted light, 40 000 times that seen with the naked eye. Observations have been made, using a Plumbicon closed circuit television system coupled to the intensifier, of fish schools, individual fish, and objects towed at varying depths beneath the surface, in water masses with what may be considered to be extremely low concentrations of luminescing organisms. Results of these tests strongly suggest that low-level light sensors may be used effectively from high altitudes as means for locating and possibly identifying pelagic fish stocks over large oceanic areas.

6 CONCLUSIONS

The remote sensing system, which is expected to evolve from this research, will have both day-time and night-time sensing capabilities. It will scan wide areas of the ocean at high speeds and provide real time data on the location, quantity, and species of pelagic fish stocks in the area under surveillance with a high degree of accuracy. Information obtained could be relayed immediately to commercial fishing vessels in the area and to receiving stations on shore, which would disseminate the data to the commercial fishing industry.

The impact of an airborne/spaceborne sensing system on the commercial fishing industry would be dramatic. It would result in large-scale reductions in search time and, therefore, in operating costs per unit of catch. It may also make possible, profitable fishing on stocks now impossible to locate with sufficient accuracy to permit economical operations. The synoptic data which would be provided by such a system would enable us to determine the fishery potential of a particular area in terms of availability and degree of utilization. It would also permit systematic appraisals of the near-surface fishery potential of wide oceanic areas such as the Caribbean. A potentially far more significant use of the aircraft/satellite data would be in determining the movements and concentrations of fish over space and time, which would provide us with the ability to predict when and where various species of fish can be taken at lowest cost.

THE STATE OF SHRIMP RESOURCES IN VENEZUELA

by

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On two previous international occasions I have talked about Venezuelan shrimp: at the Gulf and Caribbean Fisheries Institute of three years ago, and at last year's FAO Conference on the Biology and Culture of Shrimps and Prawns in Mexico City. Many of you have therefore heard me speak on this subject before. I do not want to repeat myself unnecessarily. Reference should be made to the published Proceedings of these two meetings instead. I want only to discuss, very briefly, recent developments in the Venezuelan shrimp fishery, and in our shrimp research, that might be of particular interest to this Symposium.

Shrimp is the most valuable of Venezuela's fisheries resources. Its potential value as an exportable commodity has produced a rapid development in its exploitation over a relatively short period of time, and in the last few years Venezuela has been an important contributor to the world shrimp production.

Fishing effort is concentrated in the western end of the country where approximately 96 percent of the national production is found (Figure 1). In recent months effort has been made to exploit more effectively smaller shrimp stocks in the east. Hand nets are employed in inshore waters and American-type otter trawls fish offshore.

Considerable public and private attention has recently been directed toward the industry, due at least in part to the rapid expansion of the trawler fleet and a corresponding drop in overall production. From 1958 to 1965 production figures show a sharp increase in total production. In 1965, Venezuela exported 12 719 000 lb to the U.S.A. Large investments in new processing facilities and additional trawlers resulted from increased optimism. Then in 1966, production dropped to less than half that of the previous year with drastic consequences to the industry. The 1967 and 1968 production has only partially recovered the loss (Figure 2).

What has happened? We do not really know, but perhaps an "educated guess" or two can be extracted from results of investigations of the resource realized the past four years by the Venezuelan Institute for Scientific Investigation (IVIC) in Caracas, in cooperation with the University of Miami, and from data collected more recently by the FAO/UNDP Fishery Research and Development Project in Venezuela.

At first we tried to explain the drop in production as resulting from the kind of cyclic fluctuations in population size that are observed in other shrimp fisheries, but this does not seem to be completely satisfactory.

More recently some have postulated that the resource has been overfished, and there is some evidence to support this.

However, our data seem to suggest that more basic changes in the environment may be responsible. In order to analyse this point of view we must first understand that the fishery in the west is divided into two parts. Generally speaking, the Maracaibo based trawlers fish the white shrimp populations of the inner Gulf, while the Punto Fijo based trawlers fish brown and pink shrimp in the outer Gulf. Unfortunately, Government statistics do not distinguish species. But except for 1965 (when some of the Punto Fijo boats fished white shrimps) production figures from the two ports can be used to roughly indicate total production trends for the two groups of species.

We see a steady increase in the production from Punto Fijo as the trawler fleet increases in size and efficiency, while we see a tremendous drop recently in production from Maracaibo where the fishing effort has remained steady over the past several years (Figures 2 and 3).

If this is so, we probably cannot claim overfishing of the brown and pink shrimp stocks. As the fleet has grown, catch/unit effort has dropped off somewhat, but total production has increased.

The size of white shrimp stocks (Maracaibo production) seems to have decreased and catch/unit effort has likewise dropped dangerously low, while effort remains steady.

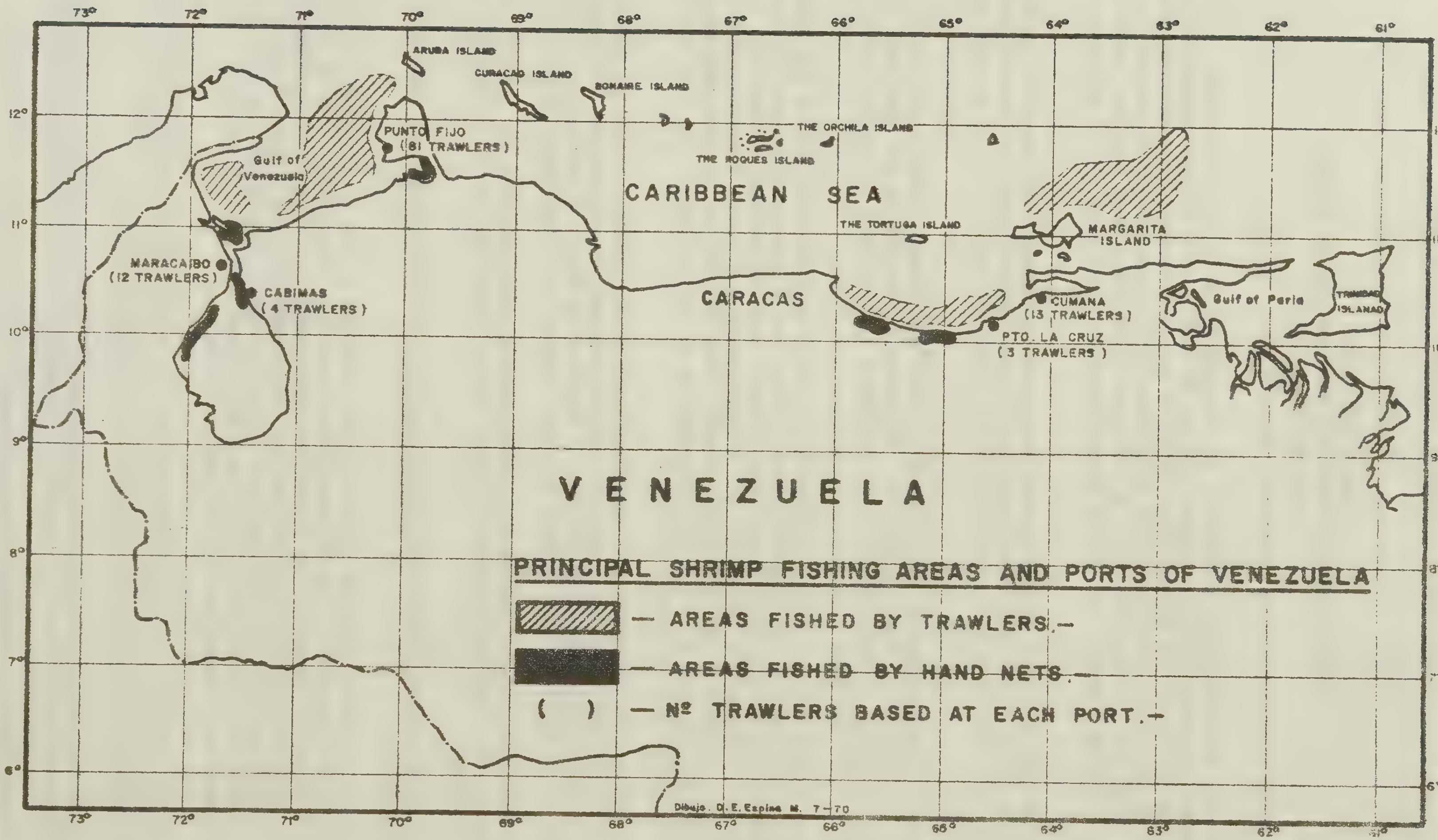
ARUBA ISLAND
CURACAO ISLAND
BONAIRE ISLAND
THE ORCHILA ISLAND
THE ROQUES ISLAND
CARIBBEAN SEA
THE TORTUGA ISLAND
MARGARITA ISLAND
PUNTO FIJO (81 TRAWLERS)
Gulf of Venezuela
MARACAIBO (12 TRAWLERS)
CABIMAS (4 TRAWLERS)
CARACAS
CUMANA (13 TRAWLERS)
PTO. LA CRUZ (3 TRAWLERS)
Gulf of Paria
TRINIDAD ISLAND
VENEZUELA
PRINCIPAL SHRIMP FISHING AREAS AND PORTS OF VENEZUELA
▨ — AREAS FISHED BY TRAWLERS.-
■ — AREAS FISHED BY HAND NETS.-
( ) — Nº TRAWLERS BASED AT EACH PORT.-
Dibujo. O.E. Espina M. 7-70
73° 72° 71° 70° 69° 68° 67° 66° 65° 64° 63° 62° 61°
12° 11° 10° 9° 8° 7° 6°

Fig. 1 Principal shrimp fishing areas and ports of Venezuela

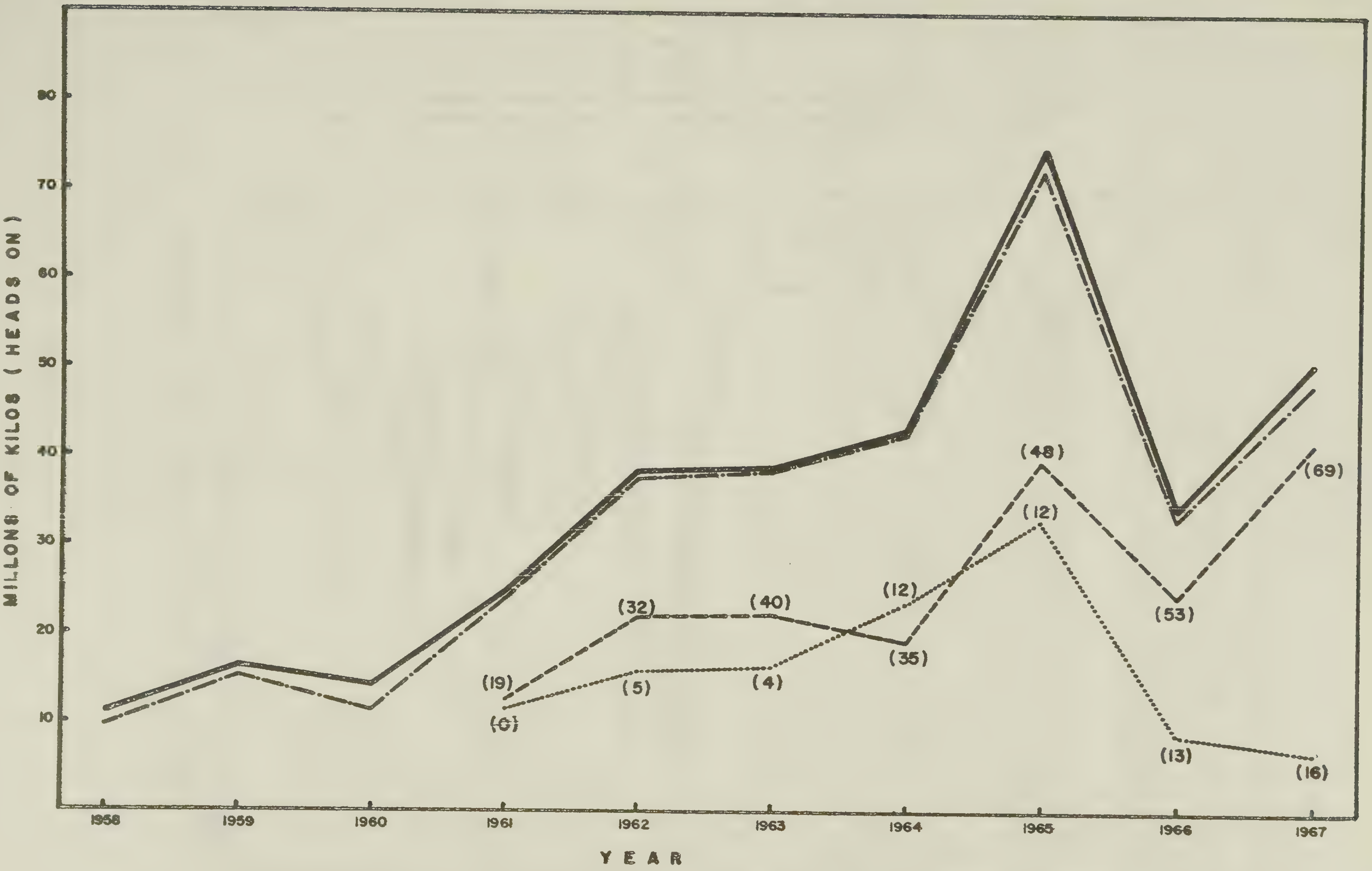

Fig. 2 Venezuelan shrim production (1958-1967)

═ Total shrimp catch - Venezuela - by year
-·-· Shrimp catch from western zone of Venezuela (Lake of Maracaibo - Gulf of Venezuela)
(
--- Shrimp catch reported from Punto Fijo } Western Zone
···· Shrimp catch reported from Maracaibo } Western Zone
( ) Number of trawlers fishing

4.19

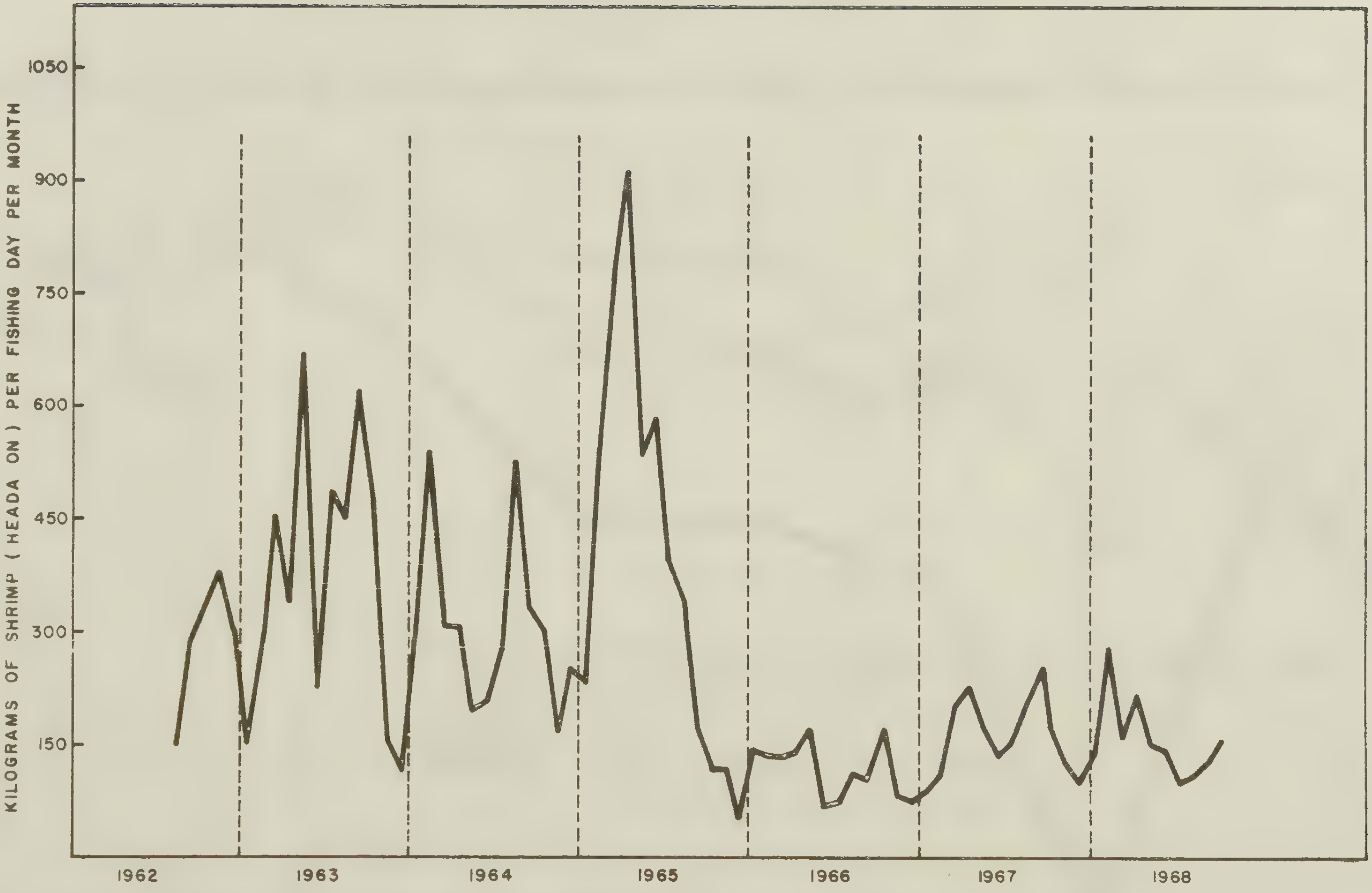

Fig. 3 Average monthly catch per fishing day of four american - type shrimp trawlers fishing out of Maracaibo - Venezuela, for the period 1962-1968

The problem therefore seems to be with the white shrimp. It might be due to overfishing but our information suggests that another possibility may be responsible, or at least play a major role.

In the early 1950's a deep-water navigation canal was dredged through the sill that had partially separated the Gulf of Venezuela from the Lake of Maracaibo. Since then the salinity of the Lake has increased at a steady rate as sea water has penetrated the Lake. There is good evidence to show that as salinity has increased there has been a series of changes in the juvenile shrimp populations of the area. Old time fishermen of the area say that after the canal was opened there first appeared large numbers of shrimp in the northern part of the Lake and that, as time has passed there has been a migration southward of the fishable populations.

For four years now we have been sampling the shrimp populations of the Lake. We have data to show that a transition is taking place. White shrimp have moved further into the Lake and been reduced in numbers, whereas brown shrimp (P. aztecus) have increased in numbers in most of the northern area. This is not as evident in the commercial catches as it is in our samplings with more efficient gear, as the brown shrimp leave the estuary at a much smaller size. It is logical to suggest that the change in salinity is affecting the distribution of the shrimp populations of the Lake.

Our size-species distribution studies and recent mark-recapture experiments have shown that the Lake serves as the most important nursery area for the white shrimp of the Inner Gulf. Changes in the estuary will be reflected outside in the Gulf, and I suggest that this is what may be happening.

More specific information is needed to prove this. The Fishery Research and Development Project has programmed projects which should give us this type of data.

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REQUINS DE GUYANE

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1 LISTE DES REQUINS DU PLATEAU CONTINENTAL DES GUYANES: NOTES DE BIOLOGIE

1.1 Famille des CARCHARHINIDAE
Genre Carcharhinus

Carcharhinus porosus (Ranzani)

Petite espèce surtout benthique. Très commun de la côte à 30 m de profondeur, se raréfie plus au large et tend à disparaître vers 70 m.

La reproduction a lieu de juillet à janvier, les jeunes à la naissance mesurent entre 29 cm et 34 cm. Les jeunes C. porosus ont une distribution semblable à celle des adultes. Le nombre de foetus est de 3 à 8 chez les porosus de 90 à 99 cm.

R. Au Brésil, de MANEZES, a mentionné cependant le nombre de 16 embryons chez un porosus de longueur non précisée.

Carcharhinus acronotus (Poey)

Requin benthique de petite taille, peu abondant. Habitat dans les fonds de 40 à 55 m.

Coloration caractéristique gris-jaune. Lobe de la deuxième dorsale noir, coloration n'atteignant pas le bord antérieur. Pectorale au bord postérieur blanc et au bord antérieur gris-brun. Bord postérieur du lobe caudal inférieur gris-noir, la coloration foncée, s'étend un peu au-dessus de l'échancrure. Le plus grand exemplaire observé par nous mesurait 110 cm.

Carcharhinus leucas (Müller et Henle)
Bull shark, ground shark

Requin de grande taille surtout benthique, commun dans toutes les mers tropicales venant en première place parmi les espèces capturées près de la côte.

Caractéristique par sa large tête, la brièveté du museau, l'absence de ride dorsale, les longues pectorales, l'origine de l'anale postérieure à celle de la deuxième dorsale chez les jeunes et souvent chez les mâles adultes.

Comme chez la plupart des grands requins les marques de couleur des adultes sont peu caractéristiques. Chez les jeunes de moins de 100 cm, par contre, les marques foncées sont spécifiques: sommet et bord postérieur de la deuxième dorsale noirs, lobe de l'anale gris-noir. Lobe inférieur caudal, bord supérieur du lobe caudal supérieur noirs.

Reproduction en septembre-octobre. On trouve en octobre au marché de Cayenne des jeunes leucas (non embryons) de 68 à 70 cm venant de naître.

4.36

Carcharhinus falciformis (Müller et Henle)

Surtout pélagique. Pêché à partir de 35 m de profondeur, abondant sur les fonds à "red snapper" (Lutjanus aya) entre 80 et 140 m. Les gros requins (poids voisin de 150 kg) qui accompagnent, isolés ou par deux, les chalutiers à crevettes, appartiennent à cette espèce. Ils se trouvent alors sous la meute des C. limbatus se déplaçant en surface.

Coloration: la teinte grise de la première dorsale s'atténue d'avant en arrière où le bord vertical apparaît très clair. La pectorale a la pointe noire. Le lobe de l'anale presque noir chez les jeunes apparaît seulement bordé de noir chez les C. falciformis de plus de 160 cm. Parfois le bord postérieur de la caudale est également noir.

Le plus grand exemplaire observé mesurait seulement 172 cm, il était loin d'être adulte (maturité vers 210 cm), le plus petit 87 cm.

Carcharhinus oxyrhynchus

Benthique. Très commun de la côte à 8 m de profondeur, abondance maximum vers 4 m. Le plus grand exemplaire observé à Cayenne mesurait 160 cm.

Période principale de reproduction en novembre-décembre.

Carcharhinus limbatus (Müller et Henle)
Black tipped shark

Plus pélagique que benthique, limbatus est aussi le seul requin à apparaître régulièrement en surface. Il est abondant de la côte jusqu'à 60 m de profondeur. Des bancs de 50 à 150 C. limbatus de toutes tailles peuvent être observés dans le sillage des chalutiers à crevettes.

Les chalutiers de Guyane française se débarrassent chaque jour de cent tonnes de poissons dont près de la moitié est dévorée par les "black tipped".

L'habitat le plus constant est situé entre les isobathes de 20 m et de 40 m. Facilement identifié au museau pointu, à la forme trapue du corps, à la nageoire dorsale élevée à la pointe et au bord vertical noirci, à la coloration noire des pointes des pectorales, du lobe caudal inférieur, de la deuxième dorsale et des pelviennes. La maturité chez les femelles est atteinte à partir de 158 cm, le nombre d'embryons varie de 4 à 9, les naissances ont lieu au printemps.

De nombreux jeunes de 69,5 à 75 cm (non embryons) ont été trouvés à la fin de mai dans les fonds inférieurs à 5 m.

Carcharhinus springeri (Bigelow et Shroeder)

Surtout benthique. Commun dans les fonds à "red snapper". Deux exemplaires de 230 à 248 cm pris au cours d'une sortie au nord de Belem.

Genre Rhizoprionodon
Sharp-nosed shark

Rhizoprionodon lalandei (Valenciennes)

Petite espèce benthique à comportement grégaire variable.

L'habitat de 3 à 70 m est identique à celui de Carcharhinus porosus. Les deux espèces sont associées lorsqu'il y a similitude de taille.

R. porosus est pêché en grand nombre par les chalutiers à crevettes, entre 50 et 60 m, au début de l'été au nord de Belem. Le plus petit exemplaire, 32 cm a été pris à 50 m, ce qui pourrait indiquer une reproduction au large.

Rhizoprionodon porosus (Poey)

Cette espèce surtout benthique est nettement plus grande (max. 108 cm) que lalandei qui ne dépasse pas 77 cm.

Nous n'avons pas remarqué porosus dans les prises de chalut. Il a été pris bien plus au large, de 130 à 140 cm, en recherchant Lutjanus aya à la ligne de dérive. Deux exemplaires pris à cette profondeur en novembre mesuraient 88 cm (♂) et 94 cm (♀ avec 5 foetus).

A São Paulo, V. Sadowsky a trouvé une répartition semblable des deux Rhizoprionodon, l'espèce du large, porosus, se limitant à 30 m à cause des basses températures.

Genre Negaprion (Whitley)

Negaprion brevirostris (Poey)
Sand shark, lemon shark

Benthique de taille moyenne. Ne semble pas s'éloigner au-delà de l'isobathe de 15 m.

Reconnaissable à la deuxième dorsale presque aussi élevée que la première dorsale, le museau court, les dents longues et pointues. En Guyane, la reproduction paraît s'étendre à la plus grande partie de l'année avec un maximum en juin et en janvier. Les jeunes à la naissance mesurent entre 38 et 41 cm de longueur standard.

Genre Galeocerdo

Galeocerdo cuvier (Lesueur)
Tiger shark, tintorera

En Guyane française sa présence près du rivage est en relation avec l'arrivée des tortues qui viennent pondre d'avril à août. Elle s'accompagne également d'une plus grande concentration de C. leucas intéressé par les tortues et par les bancs de "mâchoirans" blancs saisonniers venus à ce moment (Arius p. sp.).

1.2 Famille des SPHYRNIDAE
Genre Sphyrna

Sphyrna mokarran (Rüppell)
Great hammerhead

Rencontré à la côte et en plein océan, sa grande dispersion en fait un requin de capture peu fréquente.

Dans la région de Cayenne (profondeur de 3 à 5 m) moins d'une dizaine d'adultes (de 2,90 à 3,60 cm) sont pris chaque année au filet.

Comme dans toutes les autres mers tropicales, les très jeunes mokarran sont rarement capturés. Un exemplaire de dimensions L.T.67 cm L.S.46,5 cm a été trouvé par le CALAMAR au nord des îles du Salut à 40 m de profondeur, il s'agissait d'un mokarran venant de naître.

Sphyrna tudes (Valenciennes)
Hammerhead

La coloration vive jaune-orange étendue sur tout le corps à l'exception du dos et des lobes oculaires est caractéristique de cette espèce benthique. La largeur de la tête et sa forte courbure rappelle S. lewini, espèce plus grande que nous n'avons pas rencontrée sur le plateau continental guyanais.

La reproduction a lieu surtout en décembre-janvier; elle paraît avoir lieu très près de la côte. La maturité est atteinte à partir de 100 cm, les jeunes à la naissance mesurent 30 cm moyenne. S. tudes voyage de la côte jusqu'à 30 m de profondeur. A la côte il est dispersé, les bancs de tudes jeunes à subadultes de 65 à 82 cm sont par contre fréquents dans les fonds d'une vingtaine de mètres. Les expériences du CALAMAR ont montré que les concentrations de tudes se trouvaient en eau moins profonde l'été que l'hiver (août 20 m, février 27 m).

Sphyrna tiburo (Linné)
Bonnet shark, shovelnose

De petite taille, indentifiable à sa tête qui est la plus étroite parmi celles des requin-marteau. Espèce benthique.

En été, tiburo est associé à tudes entre 18 et 22 m, pendant l'hiver il voyage également à des profondeurs un peu plus grandes (de 28 à 30 m). La profondeur maximum ne paraît pas dépasser 50 m.

A la naissance il a la même taille que tudes (moyenne 28 cm). La reproduction a lieu en hiver de décembre à février en eau relativement profonde. Le plus petit tiburo (non embryon) mesuré (29 cm) a été pris au nord des îles du Salut à 48 m.

Sphyrna nana (Sadowsky)

Citée à titre d'indication. L'espèce est rare au large des Guyanes où son habitat paraît identique à celui de S. tiburo. Voisin de tiburo et surtout de media (Panama) auquel il a été identifié par Gilbert. La comparaison prochaine des deux S. nana pris par le CALAMAR avec les S. media en collection, permettra de mieux démontrer les différences spécifiques.

1.3 Famille des MUSTELIDAE
Genre Mustelus

Mustelus higmani (Springer et Lowe)
Smooth dogfish

L'espèce a les caractères de Mustelus: tête déprimée, oeil allongé, deux dorsales bien développées, M. higmani étant surtout différencié par la coloration dorsale jaune-orange à jaune-citron.

Espèce répandue des fonds de 20 à 70 m, sur sable vasard. Capturée en quantité appréciable au printemps au large du Cap Orange et du Surinam par les chalutiers (180 kg par journée de chalutage). Le meilleur habitat est entre 35 et 50 m. La longueur moyenne est de 48 cm. A la fin de février quelques jeunes venant de naître ont été retenus dans le chalut du CALAMAR malgré leur petite taille (21 cm).

1.4 Famille des ORECTOLOBIDAE
Genre Ginglymostoma

Ginglymostoma cirratum (Bonnaterre)
Nurse shark

Les adultes sont pris en petit nombre (environ 10 par an et par chalutier) au large. Des jeunes de 80 à 85 cm sont pris accidentellement à l'hameçon à moins de 3 m de profondeur en hiver.

2 POSSIBILITES DE PECHE

2.1 Lignes

En Guyane française des lignes ont été utilisées, sur le fond ou entre deux-eaux (à l'aide de flotteurs) par un petit nombre d'expérimentateurs à l'embouchure de l'Oyapock, aux îles du Salut à Organabo. Des requins pris n'étaient en général conservés que le foie, les ailerons, les mâchoires.

Entre 2 et 10 m de profondeur, un espacement convenable des avançons de la ligne posée sur le fond est de 5 à 7 brasses. L'appât est constitué par les Arius abondants ou tout autre poisson de taille moyenne (Centropromus, Cynoscion) ou grande. Les poissons de taille moyenne (1 kg) sont fendus en long, une moitié est alors suffisante pour un hameçon et la chair exposée est plus attirante. Par ordre de fréquence les requins capturés sont alors: Carcharhinus limbatus, C. leucas, Negaprion brevirostris, Galeocerdo cuvier; par importance de poids l'ordre est modifié: C. leucas, N. brevirostris, Galeocerdo, C. limbatus.

Entre 10 et 20 m en ajoutant des flotteurs (capacité environ 15 l), à raison d'un tous les trois ou quatre avançons (ces derniers étant un peu plus espacés que précédemment), la ligne est maintenue entre deux-eaux. Les appâts suspendus ont alors une meilleure présentation et grâce à la réaction des flotteurs les grands requins tels que: C. leucas et Galeocerdo exercent une action moins brusque sur la ligne. A cette profondeur Negaprion est en nette diminution.

En plaçant dans les fonds inférieurs à 20 m une palangre de cinquante hameçons (japonais, mustad à thons ou à requins) longue d'environ quatre cents brasses on peut obtenir 2 tonnes de requins. Il est probable que le rendement doit être meilleur avec plusieurs pièces de lignes de 150 à 200 brasses écartées d'une distance de l'ordre du mille.

Il paraît difficile d'employer la ligne fixe à multiples hameçons au-delà de 30 m à cause de la force croissante du courant.

Au-delà de 60 m (fonds à "red snapper", *Lutjanus aya*), en approchant de la rupture de pente du plateau continental (75 brasses), la ligne dérivante permettrait la capture de *Carcharhinus falciformis*, *C. springeri* et *C. obscurus*. Ces trois requins sont ceux qui limitent le rendement de la pêche au "red snapper".

Signalons enfin que la ligne à main a permis à des bateaux du Vénézuela mouillés à proximité des îles Enfant Perdu et Connétable de prendre dans des conditions mal définies cinq à sept tonnes de *Carcharhinus leucas* et *C. limbatus* en quelques heures.

2.2 Filets fixes

Ils ont été utilisés avec succès pendant une douzaine d'années dans les fonds de 3 à 5 m devant les plages d'Organabo. Les difficultés de la vente de l'huile de foie ont entraîné un arrêt de cette pêche.

2.3 Chalut

Il convient à la capture de tous les petits requins de fond d'allure lente *Carcharhinus porosus*, *C. acronotus*, *Rhizoprionodon lalandei*, *Mustelus higmani*, et surtout de *Sphyrna tudes* et *S. tiburo* qui sont les espèces les plus grégaires. En petit nombre *Carcharhinus limbatus*, *C. leucas*, *C. falciformis*, se laissent entraîner accidentellement dans le chalut malgré leur puissance de marche.

Notes

Les longueurs exprimées en centimètres désignent la longueur totale à l'exception de deux pour lesquelles il a été précisé, longueur standard.

Les caractères de couleur ont été donnés quand ils pouvaient compléter ceux des ouvrages classiques.

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PESCA EXPLORATORIA EN LA COSTA N Y N E DE SUR-AMERICA

por

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1 INTRODUCCION

En 1962, la Estación de Investigaciones Marinas de Margarita comenzó su programa de exploración pesquera en Guayanas con el NEREID, barco camaronero norteamericano del tipo corrientemente utilizado en el Golfo de México y costas orientales de U.S.A. (Fundación La Salle, 1962). A partir de esas primeras exploraciones que tuvieron por objeto la prospección de camarones, el programa de exploración pesquera se ha continuado prácticamente sin interrupción hasta el momento presente. A partir de 1966, las exploraciones se realizaron con la M/N La Salle (Hno. Ginés, F. Cervigón, 1968), siempre centrando la atención en la región de las Guayanas y ampliando paulatinamente el área de sus operaciones, hasta llegar a la Guayana Francesa en el presente año.

En 1967, comenzó la explotación pesquera al arrastre en la región de isla Margarita y zonas adyacentes y la Estación pudo recoger con continuidad y exactitud los datos de captura y situaciones por lo que en el plazo de un año se consiguió acumular una considerable información de varios barcos comerciales, todos ellos de tipo camaronero norteamericano cuyas características generales son las siguientes:

Eslora:	de 22 a 32 metros
Desplazamiento:	240 - 380 Toneladas (R.B.)
Aparejo:	Dos redes camaroneras de 350 mallas en la relinga de corchos y una pulgada de abertura

Después de 6 años de continuadas exploraciones, parecía conveniente realizar una evaluación general de los resultados y presentarlos en la forma mas clara y útil posible para todas las personas interesadas en los problemas pesqueros, tanto desde el punto de vista científico como industrial.

En publicaciones anteriores, los resultados se expresaron en kg/arte/hora (kg/a/h) por áreas ecológicas (Fundación La Salle, 1963, 64 y 65; F. Cervigón, 1965; Hno. Ginés y F. Cervigón, 1968) por considerarlo mas representativo. Al recopilar ahora los resultados de todas las exploraciones, el número de arrastres en las distintas áreas parece suficientemente grande como para considerar de mas utilidad práctica el expresarlos en kg/ha y por cuadrículas, conforme al uso normalmente seguido en este tipo de trabajos. No obstante, nos parece conveniente insistir en que, en zonas como la de Guayanas, donde los cambios de fauna son sumamente acusados de unas facies de sedimentos a otras, los resultados por cuadrículas pueden llevar a error y no representan en conjunto lo que cabe esperarse en una determinada situación, ni en cantidad, ni en composición de la fauna.

La conversión a kilos por hectárea trae consigo algunas inexactitudes ya que es difícil calibrar la velocidad exacta de la embarcación y la abertura de la boca de la red. Sin embargo, cuando como en nuestro caso existe un número razonablemente elevado de arrastres, los resultados son mas expresivos que en kg/a/h y permiten unificar y hacer mas comparables las capturas efectuadas por diversos barcos y artes. Además, en trabajos anteriores (*op. cit.*), los resultados se expresaron en kg/a/h, de manera que su presentación actual en kg/ha amplía la información y estandardiza los resultados. Todos los arrastres se han efectuado entre las 3 y las 60 brazas, en fondos blandos, de fango y arena y a lo sumo cascajo. En total, se analizaron 1 431 arrastres, habiéndose desechado algunos realizados con otros tipos de embarcaciones de características diferentes que no aumentaban sustancialmente la información y podían mas bien perturbar homogeneidad de los resultados.

La estimación en peso de las caladas se hizo en base a la capacidad de las cajas comerciales: 10 kg aproximadamente para la flota comercial y 40 kg para la M/N *La Salle*.

Los resultados expresados en los mapas (véase Apéndice II) de kg/ha para cada especie se calcularon en base al número de arrastres en que esa especie apareció, no al total de los arrastres efectuados en la cuadrícula; por ese motivo se indica también el porcentaje de arrastres en que apareció. Las áreas de mayor concentración de determinada especie se señalan con trazos mas gruesos.

En el Apéndice III se da una lista de los peces capturados en los mares de Guayanas por las expediciones de la M/N *La Salle*.

2 AREAS EXPLORADAS

Las exploraciones abarcan dos áreas geográficas definidamente separadas: la de la costa norte de Venezuela desde el Cabo Codera (Lat. 10°35' Long. 66°02') hasta la parte oriental de la península de Paria (Lat. 10°45' Long. 61°51') y la región de Guayanas, desde la boca de las Serpientes hasta el río Maroni (Guayana Francesa). Entre ambas quedan dos pequeñas regiones: el Golfo de Paria que aunque ecologicamente se puede adscribir a la región de Guayanas, por constituir un área geográfica bien definida y limitada, la tratamos separadamente y la región del NE del Drago o N de Trinidad que es una típica zona de frontera, tanto hidrográfica-como faunísticamente considerada.

La región del N de Venezuela se ha subdividido en dos: la de Anzoátegui que acupa toda la amplia bahía comprendida entre Cabo Codera y el extremo occidental de la península de Araya y la de Margarita que va desde el límite oriental de la anterior hasta la península de Paria (Lat. 10°45' Long. 61°51').

2.1 Sub-área I - Anzoátegui

Los fondos de toda la plataforma son fangosos o fangoso-arenosos; no existen obstáculos para el arrastre. El total de los arrastres analizados en esta subárea es de 429 y fueron realizados a todo lo largo del año 1968.

Fauna: Prácticamente no existe ninguna especie dominante. Se capturan numerosas especies de fondo, la mayoría de las cuales tiene poca importancia comercial para el consumo en fresco; se aprovechan para este propósito las siguientes especies que se distribuyen practicamente por toda el área:

Cazón: Diversas especies de tiburones y rayas de los géneros *Carcharhinus*, *Rhizoprionodon*, *Mustelus* y *Dasyatis*

Coro-coro: *Orthopristis ruber* y otros Pomadasydae del género *Haemulon*

Cuna: *Mycteroperca* spp.

Corvina: *Cynoscion* spp.

Lamparosa: *Vomer setapinnis*

Caitipa: *Diapterus* sp

Lenguado: *Paralichthys tropicus*

Paguara: *Chaetodipterus faber*

Catalana: *Priacanthus arenatus*

Pargo: *Lutjanus* spp. (principalmente *L. synagris*)

Roncador: *Micropogon furnieri*

Camarones: *Penaeus* spp.

Las mejores capturas corresponden a la caitipa y al camarón.

Rendimientos: En general, los rendimientos son comercialmente provechosos. Se aprecian mejores rendimientos en la mitad occidental. El total de lo que se aprovecha para la captura en fresco es siempre menor que lo que se desecha. Las caitipas dominan claramente en la mitad occidental y representan aproximadamente el 47% de la captura comercial en esa determinada zona alcanzando el camarón el 33% en la zona de su máxima abundancia.

2.2 *Sub-área II - Margarita-Tierra Firme*

Al norte de la Península de Araya y en parte de la del Golfo de Paria los fondos son fangosos hasta la isobata de 35 metros aproximadamente. Entre la isla Margarita y el continente existen zonas rocosas. Al norte de Margarita, en la bahía de la Arrestinga hay una pequeña zona de fondos fangosos. Al sur del archipiélago de Los Testigos existe una amplia zona coralina, no rastreable. El resto del área de una plataforma es arenoso-fangoso y arenoso, algunas veces con cascajo.

En esta área se analizan 625 arrastres, todos ellos correspondientes al año 1968.

Fauna: Son frecuentes los arrastres en que aparecen mas de 40 especies, llegando en ocasiones hasta 50, sin que aparezca con claridad ninguna especie dominante. Sin embargo, tienen especial importancia el coro-coro (*Orthopristis ruber* y *Haemulon* spp.), el panchito (*Pristipomoides aquilonaris*), el pargo (*Lutjanus* spp., especialmente *Lutjanus synagris*) y, por su rendimiento económico, el camarón (*Penaeus* spp.)

El coro-coro se encuentra distribuído por toda el área, pero se aprecia claramente una mayor abundancia al este de isla Margarita entre las 20 y las 40 brazas, en fondos arenosos o arenoso-fangosos.

El panchito se concentra con claridad en profundidades de 30 a 50 brazas y en fondos de arena o de cascajo; en general, siempre a mayores profundidades que el coro-coro.

Los camarones se extienden también por una amplia zona pero con tendencia a concentrarse al NE de Margarita.

Otra especie importante es el lenguado, representado principalmente por *Paralichthys tropicus*, que puede alcanzar una talla de 50 cm de longitud.

Rendimientos: Las capturas totales oscilan entre 8 y 50 kg/ha. Las cifras mas altas corresponden a la zona situada al este de Margarita en profundidades de 15 a 30 brazas. Normalmente la captura para la venta en fresco es menor que aquella que se desecha, especialmente en los fondos fangosos próximos al continente (cuadrículas L, M-8), diferencia que se atenúa a profundidades mayores y en fondos mas consistentes y, en ocasiones, el total de la captura para la venta en fresco supera la porción desechable. En la cuadrícula J-6 se alcanzó un rendimiento de 82 kg/ha, lo cual supera en mucho la media general aunque, siendo su resultado el promedio de solamente ocho arrastres, no puede considerarse como representativo.

Coro-coro: En el área de su máxima abundancia (I-J, 6, J-5) los rendimientos de coro-coro están entre 12.72 y 14.14 kg/ha y representa el 36% de la pesca comercial total en esas cuadrículas;

aisladamente es la especie que da mas alto rendimiento en peso.

Panchito: Se captura en un área mas reducida que el coro-coro y en general su rendimiento promedio también es menor. Un rendimiento de 5.68 kg/ha en la cuadrícula H-3 en un conjunto de 186 arrastres es la cifra mas representativa. Constituye el 38% de la captura comercial en la zona de máxima abundancia. Es una especie apreciada para la venta en fresco.

Camarones: Son especialmente abundantes al NE de Margarita. Sus rendimientos no son muy elevados pero aparecen en general en un porcentaje muy alto de los arrastres efectuados. El valor económico de este crustáceo hace que la pesquería en conjunto resulte rentable. Representa aproximadamente el 22% de la captura comercial en la zona de su máxima abundancia.

Todas las demás especies representan por separado una porción muy escasa de la captura total, pero algunas especies como el mero y el pargo (Epinephelus spp. y Lutjanus spp.) tienen un alto valor en el mercado. El roncador (Micropogon furnieri) es también una especie muy abundante y en algunos sectores de rendimientos apreciables; aproximadamente representa el 13% de la captura comercial.

2.3 Sub-área III - NE Boca del Drago-Paria

Al N de Trinidad, la especie dominante es la lamparosa (Vomer setapinnis) pero su abundancia es irregular, habiéndose realizado en ocasiones capturas de mas de 1 000 kg/h de arrastre y en otras escasas cantidades. Su presencia es constante en casi todos los arrastres.

El resto de las especies representa un porcentaje muy escaso de la pesca total. Los fondos son arenosos con algunas rocas aisladas. Es una de las pocas áreas en que la captura de la porción aprovechable para la venta en fresco es considerablemente mayor que la de desecho.

En el Golfo de Paria los rendimientos son mucho mas bajos que al N de Trinidad. La especie mas importante es la corvina y curvinato, representados por las especies Cynoscion virescens y C. bairdi principalmente.

Los fondos son fangosos y con dificultades para el arrastre. Otra especie abundante es el roncador (Micropogon furnieri).

En esta área se analizan 79 arrastres.

2.4 Sub-área IV - Guayanas

A lo largo de todas las costas de Guayanas se diferencian tres fases bien definidas en la plataforma, reconocidas por casi todos los autores: la de los fondos fangosos próximos a la costa o de pescado amarillo, la de fondos arenoso-fangosos o de pescado blanco y la de los fondos arenosos con algo de cascajo o de pescado rojo. Estas tres facies, mas o menos paralelas a la costa, tienen distinta anchura en los diferentes lugares (Hno. Ginés y F. Cervigón, 1968). Los rendimientos de la pesca aumentan gradualmente hacia el SE para llegar a un máximo frente a las costas de Surinam con un promedio de 45 kg/ha en el 35-S, zona de pescado blanco; por debajo de las 25 brazas la abundancia es considerablemente menor.

En toda esta sub-área, la especie comercial mas importante y mas abundante es la corvina (Cynoscion virescens), cuyos rendimientos máximos se producen también frente a las costas de Surinam en 35-S. Al SE de Trinidad (30-P) también los rendimientos han sido constantemente altos. Sigue en importancia el roncador (Micropogon furnieri) y, cerca de la costa, el cazón. En Guayanas la corvina representa el 41% de la pesca comercial y el roncador el 23%; en Surinam ambas especies representan el 69% y 23% de la captura comercial respectivamente. En total se analizaron mas de 300 arrastres en esta área.

2.5 Conclusiones

En relación con las posibilidades de explotación de estas pesquerías en función de los resultados obtenidos y con vistas a su posible regulación y explotación racional se pueden indicar los siguientes aspectos fundamentales de carácter general.

2.5.1 Sub-áreas Anzoátegui y Margarita-Tierra Firme El número de especies de valor comercial que se capturan en cada arrastre es considerablemente elevado, sin que ninguna de ellas predomine sobre las demás de forma clara. En el área del coro-coro, esta especie, que es la mas abundante, representa solamente el 36% de la captura que hemos considerado comercial; ello implica serias dificultades cuando se quieren establecer criterios de regulación ya que hay que atender a la biología, las tallas medias, el crecimiento, fecundidad, etc., de numerosas especies para establecer un criterio determinado sobre las vedas o el tamaño mínimo de mallas.

El máximo rendimiento económico relativo proviene del camarón; sin embargo, sus rendimientos no permiten caracterizar el área como camaronera, al menos por los resultados obtenidos en los arrastres analizados. Una pesca intensiva con redes de malla estrecha podría alterar, no obstante, el equilibrio actual y disminuyendo la cantidad de peces, favorecer el nivel trófico inferior representado entre otras especies, por los camarones.

2.5.2 Sub-área de Guayanas Las pesquerías de la región de Guayanas presentan unas características diferentes de las anteriores. Las especies comercialmente importantes son menos y en los fondos de "pescado blanco" se encuentra en forma predominante la corvina y, en proporción mucho menor, el roncador. Cualquier futura regulación de la pesquería debería pues acomodarse a las características biológicas de la corvina en los fondos en que predomina. A largo plazo probablemente esta pesquería de corvina sea mas rentable que la de Margarita - Anzoátegui, debido a sus características biológicas.

3 PESCA EXPLORATORIA - INVENTARIOS FAUNISTICOS POR ARRASTRES

En algunas expediciones se realizaron inventarios faunísticos completos de diversas caladas y se estimó el peso total de cada especie en la calada por el siguiente procedimiento:

(i) De cada calada se separó al azar una submuestra de un peso aproximado de 30 a 40 kg, mas o menos equivalente a una caja llena de las utilizadas para almacenar el pescado en la bodega.

(ii) De esta submuestra se separaron todas las especies y se pesaron.

(iii) Se estimó el peso total de la captura por el número de cajas que se llenaron, imponiendo a cada caja un peso de 40 kg.

(iv) Se estimó el peso de cada especie en el total de la calada multiplicando el peso de ella en la submuestra por el número total de cajas de la calada cuando la submuestra era una caja completa o por una sencilla regla de tres cuando la submuestra tenía un peso claramente inferior al estimado para una caja.

(v) Se hizo un inventario general de las especies presentes en la calada a fin de incorporar todas aquellas que no estuvieran representadas en la submuestra.

Este procedimiento adolece de muchos errores, ya que los peces no se distribuyen uniformemente en el copo, sino que los mas grandes y pesados tienden a acumularse hacia la parte anterior del mismo y cuando la captura queda sobre cubierta, en los bordes del montón. El error es mayor con las especies de talla grande, ya que su representación en la submuestra puede estar mas viciada. No obstante, consideramos que la información general obtenida es sumamente valiosa ya que da una idea aproximada de la estructura de las comunidades en las diversas áreas y facies. Como la malla utilizada en el copo era de una pulgada, la captura puede considerarse razonablemente representativa de la comunidad de peces bentónicos.

Cuando en las listas adjuntas no aparece señalada ninguna cantidad quiere decir que la especie estuvo presente en la calada pero no en la submuestra.

La fauna de la plataforma continental del Caribe venezolano oriental y la del Atlántico presenta diferencias notables que se manifiestan en las capturas comerciales. La especie mas importante de la región de Guayanas, Cynoscion virescens, se hace ya muy escasa al N de Trinidad y desaparece totalmente en el área de Margarita - Anzoátegui. Lo mismo sucede con otros Sciaenidae como Cynoscion bairdi y Macrodon ancylodon, que en la región de Guayanas es una de las especies mas abundantes, siendo a menudo la dominante. Otras especies también desaparecen totalmente en el área del Caribe como Dasyatis geisjkeri y, al parecer, Carcharhinus porosus. Sin embargo, Micropogon furnieri se distribuye tanto en el Caribe como en Guayanas en una proporción similar en las capturas. La presencia o abundancia de determinadas especies parece estar especialmente relacionada con el tipo de fondo y la presencia de aportes de agua dulce ya que es en la franja costera de ambas zonas donde se encuentran las mayores diferencias. En las zonas mas profundas de ambas y a partir de los 60 m aproximadamente, la composición de la fauna es muy similar.

Los resultados de las pescas exploratorias en las sub-áreas de Paria y Guayanas de indican en el Apéndice I.

4.43

APENDICE I

INVENTARIOS FAUNISTICOS POR ARRASTRES BASADOS EN PESCAS EXPLORATORIAS REALIZADAS POR LA M/N LA SALLE EN LAS SUB-AREAS DE PARIA Y GUAYANAS

1 SUB-AREA DE PARIA

Arrastre 1

Expedición: LS-38-P **Fecha:** 5-7-68 **Horas:** 06.40 - 09.40

Latitud: 10°34' - 10°29' **Longitud:** 62°02.5' - 62°13'7' **Profundidad:** 13-9 Br.

Especies	Total kg	Especies	Total kg
Mustelus higmani (5)	21,5	*Cynoscion jamaicensis*	33,5
Rhizoprionodon sp.		*Cynoscion bairdi* (1)	9,5
Sphyrna tiburo		*Cynoscion virescens* (1)	14,3
Dasyatis guttata		*Cynoscion leiarchus*	
Gymnura micrura		*Macrodon ancylodon*	35,9
Bagre marinus (6)	38,3	*Stellifer rastrifer*	29,3
Bagre bagre (3)	8,3	*Larimus breviceps*	
Arius spixii (2)	1,1	*Ctenosciaena gracilicirrhus*	3,5
Harengula sp.		*Micropogon furnieri*	196,3
Pellona harroweri	11,9	*Lutjanus synagris* (3)	19,1
Opisthonema oglinum		*Trichiurus lepturus*	25,1
Diplobatis sp.		*Chaetodipterus faber* (1)	8,9
Chirocentrodon bleckerianus	1,1	*Diapterus* sp.	19,1
Anchoa spinifer (3)		*Peprilus paru* (1)	4,7
Anchoviella sp. (1)		*Prionotus punctatus*	2,3
Sphyraena guachancho (2)	1,4	*Syacium gunteri*	
Polydactylus virginicus	7,1	*Achirus* sp.	
Vomer setapinnis		*Porichthys porosisimum* (3)	1,1
Chloroscombrus chrysurus	0,5	*Colomesus psittacus*	
Orthopristis ruber		*Diplectrum radiale* (2)	1,7
		Camarones	10,7

Peso Muestra (kg): 43,27; **Total de la Calada (kg):** 518

Arrastre 2

Expedición: LS-38-P **Fecha:** 5-7-68 **Horas:** 10.55 - 13.25

Latitud: 10°34' - 10°22' **Longitud:** 62°15' - 62°27' **Profundidad:** 11-9 Br.

Especies	Total kg	Especies	Total kg
Cetengraulis edentulus		*Trachinotus cayenensis*	
Lutjanus synagris		*Vomer setapinnis*	
Chloroscombrus chrysurus		*Chaetodipterus faber*	
Vuela chicharra		*Oligoplites* sp.	

Total de la Calada (kg): 30

Observaciones: Pesca muy probre. Se bota algo menos de una caja. El carite pintado de tamaño grande, algunos de casi un metro. *Chaetodipterus faber*, grande también.

Arrastre 3

Expedición: LS-38-P   Fecha: 5-7-68 Horas: 14.25 - 17.40

Latitud: 10°15' - 10°14,5'   Longitud: 62°24' - 62°12' Profundidad: 5-11 Br.

Especies	Total kg	Especies	Total kg
Mustelus higmani (1)	5,9	Rachycentron canadum	6,7
Sphyrna tiburo		Menticirrhus martinicensis	
Dasyatis guttata		Micropogon furnieri	29,9
Gymnura micrura (1)	6,7	Cynoscion virescens	14,9
Rhinobatos percellens	8,3	Cynoscion jamaicensis	22,4
Elops saurus (3)	25,4	Cynoscion leiarchus	31,4
Bagre marinus	82,3	Macrodon ancylodon	
Pellona harroweri	8,9	Trichiurus lepturus	44,0
Chirocentrodon bleekerianus	1,7	Chaetodipterus faber	62,8
Opisthonema oglinum (1)	2,2	Lutjanus synagris	37,4
Harengula sp. (2)	2,4	Lepophidium sp. (1)	
Lycengraulis sp. (2)	1,4	Diplectrum radiale	1,4
Muraenosox savanna (1)		Genyatremus luteus	
Synodus feotens	4,4	Scomberomorus maculatus (11)	77,8
Sphyraena guachancho	4,4	Prionotus punctatus	2,0
Caranx latus (3)	8,9	Citharienthys spilopterus	1,7
Caranx hippos (Peq.)	125,7	Achirus sp.	
Caranx crysos		Diapterus sp.	
Chloroscombrus chrysurus	8,2	Sphoeroids sp.	2,2
Selene vomer (4)	35,9	Lagocephalus laevigatus	
Vomer setapinnis (Peq.)	10,4	Porichthys porosisimum	
Oligoplites sp.		Ogcocephalus sp.	1,7
Trachinotus carolinus		Stomatopoda	
Hemicaranx amblyrhinchus	16,4	Jaibas	
Peprilus paru	5,9		

Peso Muestra (kg): 46,76; Total de la Calada (kg): 700

Observaciónes: La mayor parte del pescado llegó vivo a cubierta.

2 SUB-AREA DE GUAYANAS

Arrastre 4

Expedición: LS-38-P   Fecha: 6-7-68 Horas: 06.15-08.15

Latitud: 09°32,5' - 09°19'   Longitud: 60°39,5' - 60°33,5' Profundidad: 20-22 Br.

Especies	Total kg	Especies	Total kg
Carcharhinus porosus (2)	44,1	Micropogon furnieri (2)	10,6
Mustelus higmani (2)	9,1	Macrodon ancylodon	173,5
Sphyrna tudes (2)	4,5	Larimus breviceps (4)	9,8
Urotrygon microphthalmum		Stellifer sp.	6,8
Diplobatis sp.		Ophioscion sp.	12,1
Gymnura micrura		Cynoscion jamaicensis	
Bagre marinus	13,6	Isopisthus parvipinnis	12,1
Bagre bagre	13,6	Trichiurus lepturus	
Arius str. parm.		Peprilus paru (juv.)	
Anchoa spinifer (2)	2,2	Genyatremus luteus (1)	7,6
Harengula sp.		Ogcocephalus sp.	3,8
Centropomus ensiferus (1)		Arius sp. (1)	2,2
Epinephelus niveatus (juv.) (3)		Chilomicterus antillarum (1)	3,0
Cynoscion virescens	273,9	Camarones	5,3

Peso Muestra (kg): 40; Total de la Calada (kg): 609

4.43

Arrastre 5

Expedición: LS-38-P **Fecha:** 6-7-68 **Horas:** 09.00 - 11.00

Latitud: 09°26,5' - 09°25' **Longitud:** 60°36,5' - 60°31' **Profundidad:** 15-17 Br.

Especies	Total kg	Especies	Total kg
Carcharhinus porosus (3)	88,1	Vomer setapinnis (juv.)	15,7
Rhizoprionodon lalandei		Hemicaranx amblyrhinchus	
Mustelus higmani		Cynoscion virescens	182,6
Carcharhinus oxyrhinchus (1)		Micropogon furnieri	
Sphyrna tudes (juv.)	12,5	Macrodon ancylodon	847,0
Gymnura micrura (4)	47,2	Isopisthus parvipinnis	28,3
Urotrigon microphthalmum	3,1	Larimus breviceps	
Diplobatis sp. (3)	6,2	Nebris microps	
Bagre bagre	50,3	Stellifer sp. rastrifer	15,7
Arius spp.	94,4	Stellifer sp.	15,7
Bagre marinus		Trichiurus lepturus (1)	28,3
Dasyatis guttata		Colomesus psittacus (1)	4,7
Harengula sp. (2)	9,4	Ogcocephalus	1,5
Anchoa spinifer	18,8	Camarones	25,1

Peso Muestra (kg): 47,50; **Total de la Calada (kg):** 1 496

Arrastre 6

Expedición: LS-38-P **Fecha:** 6-7-68 **Horas:** 11.45 - 14.00

Latitud: 09°23' - 09°20' **Longitud:** 60°31,5' - 60°28' **Profundidad:** 12-16 Br.

Especies	Total kg	Especies	Total kg
Carcharhinus oxyrhinchus		Macrodon ancylodon	979,0
Carcharhinus porosus		Micropogon furnieri	3,6
Sphyrna tudes (grande)	61,6	Cynoscion virescens	29,0
Mustelus higmani		Larimus breviceps (1)	10,8
Cazón	25,3	Nebris microps	
Sphyrna tiburo		Stellifer rastrifer	0,7
Dasyatis geisjkesi		Stellifer sp.	3,6
Dasyatis guttata		Isopisthus parvipinnis	9,0
Urotrygon microphthalmum		Ophiscion sp. (1)	3,6
Diplobatis sp.		Harengula sp.	10,8
Bagre bagre (juv.)	39,8	Trichiurus lepturus (juv.)	134,1
Arius sp.	43,5	Scomberomorus maculatus	
Pellona harroweri		Peprilus paru (juv.)	87,0
Bagre marinus		Colomesus psittacus	
Anchoa spinifer	7,2	Ogcocephalus sp.	3,6
Harengula sp.	10,8	Camarones	32,6
Vomer setapinnis (juv.)	36,2	Invert. (Stomatopoda)	
Trachinotus carolinus		Otros invertebrados	10,8

Peso Muestra (kg): 42,57; **Total de la Calada (kg):** 1,544

Arrastre 7

Expedición: LS-38-P **Fecha:** 6-7-68 **Horas:** 14.50 - 16.50

Latitud: 09°19' - 09°16' **Longitud:** 60°26' - 60°22' **Profundidad:** 20-25 Br.

Especies	Total kg	Especies	Total kg
C. porosus (3)	65,0	Bairdiella sanctae-luciae	
Mustelus higmani	45,5	Micropogon furnieri	91,0
Pristis pectinatus		Isopisthus parvipinnis	28,6
Dasyatis guttata		Larimus breviceps	
Gymnura micrura	6,5	Stellifer spp.	10,4
Arius spp.	78,0	Genyatremus luteus	
Bagre bagre (12)	26,0	Polydactilus virginicus	
Bagre marinus		Trichiurus lepturus	26,0
Harengula sp. (1)	2,6	Chaetoripterus faber (juv.)	
Diplobatis sp.		Ciclopsette chittendeni	
Anchoa spinifer		Stropus crossotus	
Diplectrum radiale (1)		Achirus sp.	2,6
Macrodon ancylodon	676,0	Ogcocephalus sp.	31,2
Cynoscion virescens	169,0	Chilomicterus antillarum	
Cynoscion jamaicensis	31,2		
Cynoscion similis		Camarones	20,8

Peso Muestra (kg): 50,45; **Total de la Calada (kg):** 1 312

Arrastre 9

Expedición: LS-38-P **Fecha:** 7-7-68 **Horas:** 06.15 - 08.40

Latitud: 08°10' - 08°10' **Longitud:** 59°00' - 58°53' **Profundidad:** 10-9 Br.

Especies	Total kg	Especies	Total kg
Mustelus higmani (3)	3,1	Micropogon furnieri	
Diplobatis sp.		Cynoscion jamaicensis (6)	5,6
Pristis pectinatus (1)		Cynoscion virescens	3,7
Bagre bagre (1)	1,2	Macrodon ancylodon (2)	1,8
Bagre marinus		Umbrina coroides (2)	4,3
Arius spixii (1)	0,9	Cynoscion similis	0,9
Opisthonema oglinum	6,2	Isopisthus parvipinnis (1)	0,9
Chirocentrodon bleekerianus	0,9	Chloroscombrus chrysurus	28,1
Harengula sp.	1,8	Chaetodipterus faber (2)	1,2
Lycengraulis sp.		Scomberomorus maculatus (11)	13,2
Sphyraena guachancho (3)	15,0	Peprilus paru	7,5
Caranx hippos	103,9	Menticirrhus martinicensis	2,8
Vomer setapinnis	8,7	Trichiurus lepturus (juv.)	1,5
Hemicaranx amblyrhinchus	27,5	Diapterus sp. (3)	3,1
Pomadasys corvinaeformis	2,8	Etropus crossotus	0,3
Conodon nobilis (7)	10,0	Sphoeroides testudineus	1,5

Peso Muestra (kg): 41,47; **Total de la Calada (kg):** 260

Observaciones: P. pectinatus, unos 250 kg

4.43

Arrastre 10

Expedición: LS-38-P
Fecha: 7-7-68 Horas: 15.25 - 18.25
Latitud: 8°11'
Longitud: 58°44' W Profundidad: 20-21 Br.

Especies	Total kg	Especies	Total kg
Mustelus higmani		Trichiurus lepturus	1,3
Sphyrna tiburo		Scomberomorus cavalla	9,3
Opisthonema oglinum		Scomberomorus maculatus	
Harengula sp.	3,3	Prionotus punctatus (3)	3,3
Rhizoprionodon lalandei		Diapterus sp.	
Albula nemoptera (1)		Encinostomus sp.	26,5
Synodus sp. (2)		Halichoeres caudalis	
Sphyraena picudilla	126,3	Cynoscion similis (2)	5,3
Diplectrum radiale	6,6	Rachycentron canadum	
Selar crumenophthalmus	9,3	Scorpaena brasiliensis	
Caranx latus (5)	11,9	Syacium gunteri	1,9
Caranx crysos		Cyclopsetta chitendeni	2,6
Vomer setapinnis	11,9	Balistes vetula (j)	5,3
Hemicaranx amblyrhinchus	5,3	Alutera sp. (2)	3,9
Lutjanus synagris (1)	5,3	Monacanthus sp.	3,9
Chloroscombrus chrysurus	4,6	Chylomicterus antillarum (2)	5,9
Lutjanus purpureus (j)	13,2	Lagocephalus laevigatus	
Priacanthus arenatus (3)	4,6	Antenarius scaber	0,6
Upeneus parvus	66,4	Lactophyrs tricornis	2,6
Orthopristis ruber	9,9	Camarones	1,3
Haemulon aurolineatum		Calamares	3,9
Haemulon steindachneri	4,6	Stomatopoda	1,3

Peso Muestra (kg): 27,60; Total de la Calada (kg): 367

Arrastre 11

Expedición: LS-38-P
Fecha: 8-7-68 Horas: 06.05 - 09.00
Latitud: 06°49' - 06°44'
Longitud: 57°32' - 57°25' Profundidad: 10-10 Br.

Especies	Total kg	Especies	Total kg
Gynglimostoma cirratum		Larrimus breviceps	110,7
Rhizoprionodon lalandei		Stellifer rastrifer	
Carcharhinus porosus		Stellifer stellifer	28,8
Mustelus higmani		Stellifer brasiliensis	7,2
Sphyrna tiburo	19,2	Isopisthus parvipinnis (3)	9,6
Sphyrna tudes		Menticirrhus martinicensis	
Arius spp.	250,3	Ctenosciaena gracilicirrhus	4,8
Bagre bagre	110,7	Bairdiella sanctae-luciae (1)	7,2
Gymnura micrura	7,2	Micropogon furnieri	130,0
Dasyatis guttata (1)	101,1	Nebris microps	12,0
Urotrygon microphthalmum		Cynoscion bairdi	
Pellona harroweri	207,0	Cynoscion jamaicensis	9,6
Harengula sp.	192,6	Cynoscion virescens	105,9
Opisthonema oglinum	14,4	Cynoscion similis	
Sphiraena guachancho	24,0	Scomberomorus maculatus	
Muraenesox savanna		Scomberomorus cavalla	4,8
Polydactilus virginicus	14,4	Trichiurus lepturus	28,8
Vomer setapinnis (1)	9,6	Peprilus paru (juv.)	36,1
Hemicaranx amblyrhinchus		Prionatus punctatus	4,8
Chaetodipterus faber	9,6	Sphoeroides testudineus	4,8
Conodon nobilis		Colomesus psittacus	
Pomadasys corvinaeformis		Ogcocephalus sp.	4,8
Polyclemus brasiliensis	24,0	Diapterus sp.	
Macrodon ancylodon	683,7	Camarones	40,9

Peso Muestra (kg): 46,10; Total de la Calada (kg): 2 220

Arrastre 12

Expedición: LS-38-P Fecha: 8-7-68 Horas: 11.00 - 03.15

Latitud: 06°36' - 06°31' Longitud: 57°15' - 57°10' Profundidad: 10-10 Br.

Especies	Total kg	Especies	Total kg
Rhizoprionodon lalandei		Oligoplites sp.	11,2
Carcharhinus porosus		Selene vomer	
Sphyrna tiburo		Chaetodipterus faber (1)	2,4
Dasyatis guttata		Macrodon ancylodon	214,8
Gymnura micrura		Cynoscion virescens	
Bagre bagre	49,9	Cynoscion jamaicensis	187,3
Pellona harroweri	59,9	Cynoscion similis	12,4
Harengula sp.	39,9	Ctenosciaena gracilicirrhus	22,4
Mustelus higmani		Larimus breviceps (2)	7,4
Opisthonema oglinum (2)	6,2	Stellifer spp.	7,4
Odontognathus mucronatus	1,7	Isopisthus parvipinnis (2)	6,2
Lycengraulis sp.		Micropogon furnieri (1)	8,7
Anchoviella sp. (1)	1,2	Scomberomorus maculatus	139,8
Sphyraena guachancho	219,8	Scomberomorus cavalla	47,4
Centropomus ensiferus		Diapterus sp. (8)	37,4
Trachinotus cayenensis (1)	11,2	Peprilus paru	9,9
Vomer setapinnis	3,7		
Hemicaranx amblyrhinchus	22,4	Camarones	7,4

Peso Muestra (kg): 46,02; Total de la Calada (kg): 1 150

Arrastre 14

Expedición: LS-38-P Fecha: 8-7-68 Horas: 16.40 - 18.40

Latitud: 06°26' - 06°21,5' Longitud: 57°07' - 57°01' Profundidad: 10-13 Br.

Especies	Total kg	Especies	Total kg
Mustelus higmani		Ctenosciaena gracilicirrhus	92,3
Dasyatis americana		Isopisthus parvipinnis	60,6
Sphyrna tiburo		Larimus breviceps	23,4
Bagre marinus		Cynoscion virescens	46,8
Bagre bagre		Cynoscion jamaicensis	33,0
Arius spp.		Macrodon ancylodon	17,5
Pellona harroweri	82,7	Menticirrhus martinicensis	30,3
Harengula sp.	8,2	Polyclemus brasiliensis	5,5
Opisthonema oglinum		Stellifer brasiliensis	9,6
Sphyraena guachancho	82,7	Stellifer rastrifer	5,5
Vomer setapinnis	110,3	Diapterus sp.	110,3
Hemicaranx amblyrhinchus	41,3	Scomberomorus cavalla (1)	44,1
Oligoplites sp.	22,0	Scomberomorus maculatus (1)	8,2
Chaetodipterus faber	4,1	Peprilus paru	19,8
Pomadasys corvinaeformis	6,8	Trichiurus lepturus	
Genyatremus luteus		Prionotus punctatus	
Micropogon furnieri	96,5	Sphoeroides testudineus	2,7
Bairdiella sanctae-luciae		Colomesus psittacus	

Peso Muestra (kg): 35,35; Total de la Calada (kg): 975

4.43

Arrastre 15

Expedición: LS-38-P **Fecha:** 9-7-68 **Horas:** 19.30 - 21.30

Latitud: 06°07' - 06°13' **Longitud:** 55°47' - 55°43' **Profundidad:** 9-13 Br.

Especies	Total kg	Especies	Total kg
Carcharhinus porosus		*Vomer setapinnis*	2,6
Mustelus higmani		*Polyclemus brasiliensis*	10,6
Sphyrna tudes		*Micropogon furnieri*	238,5
Sphyrna tiburo		*Macrodon ancylodon*	180,5
Gymnura micrura		*Stellifer brasiliensis*	55,6
Arius spp.	530,1	*Stellifer rastrifer*	
Bagre bagre	58,3	*Nebris microps*	21,2
Pellona harroweri	180,2	*Cynoscion jamaicensis*	
Harengula sp.	26,5	*Cynoscion virescens*	599,0
Odonthognathus mucronatus	2,6	*Isopisthus parvipinnis*	2,6
Anchoa spinifer	74,2	*Trichiurus lepturus*	13,2
Chaetodipterus faber	7,9	*Peprilus paru*	15,9
Hemicaranx amblyrhinchus		*Sphoeroides testudineus*	
Trachinotus cayenensis		*Colomesus psittacus*	

Peso Muestra (kg): 38,10; **Total de la Calada (kg):** 2 020

Arrastre 17

Expedición: LS-38-P **Fecha:** 9-7-68 **Horas:** 11.05 - 13.15

Latitud: 06°11 - 06°13' **Longitud:** 55°11' - 55°35' **Profundidad:** 8-11 Br.

Especies	Total kg	Especies	Total kg
Mustelus higmani (2)	17,8	*Larimus breviceps*	22,2
Sphyrna tiburo		*Micropogon furnieri* (1)	26,7
Sphyrna tudes (1)	13,3	*Cynoscion virescens* (1)	22,2
Dasyatis guttata	66,7	*Stellifer rastrifer*	
Gymnura micrura	89,0	*Stellifer stellifer*	57,8
Rhinobatos percellens		*Stellifer brasiliensis*	89,0
Arius spixii	498,6	*Macrodon ancylodon*	
Bagre bagre	28,9	*Trichiurus lepturus*	396,2
Odonthognathus mucronatus (3)	4,4	*Ogcocephalus* sp. (1)	4,4
Anchoa spinifer	120,2		
Paralonchurus elegans (2)	13,3	Camarones	298,2

Peso Muestra (kg): 39,75; **Total de la Calada (kg):** 1 770

Arrastre 20

Expedición: LS-38-P **Fecha:** 10-7-68 **Horas:** 04.30 - 06.30

Latitud: 06°15'5' - 06°15'5' **Longitud:** 54°22' - 54°30' **Profundidad:** 13-10 Br.

Especies	Total kg	Especies	Total kg
Carcharhinus porosus		*Polyclemus brasiliensis*	10,5
Mustelus higmani		*Febris microps*	42,3
Sphyrna tudes		*Macrodon ancylodon*	158,9
Dasyatis guttata		*Stellifer rastrifer*	
Gymnura micrura		*Stellifer stellifer*	5,7
Narcine brasiliensis (1)		*Stellifer brasiliensis*	
Diplobatis pictus	2,1	*Isopisthus parvipinnis*	42,3
Bagre bagre	48,7	*Cynoscion virescens*	135,6
Arius spp.	140,4	*Genyatremus luteus*	
Harengula sp.	7,4	*Trichiurus lepturus*	4,2
Odonthognatus mucronatus	6,3	*Peprilus paru*	2,1

Arrastre 20 (continuación)

Especies	Total kg	Especies	Total kg
Anchoa spinifer		Achirus sp.	2,1
Chaetodipterus faber	54,0	Chylomicterus antillarum	
Paralonchurus elegans	7,4	Camarones	50,3

Peso Muestra (kg): 34,02; Total de la Calada (kg): 740

Arrastre 21

Expedición: LS-38-P   Fecha: 10-7-68   Horas: 07.20 - 09-20

Latitud: 06°17' - 06°18'   Longitud: 54°33' - 54°11'   Profundidad: 10-10 Br.

Especies	Total kg	Especies	Total kg
Gymnura micrura	33,6	Isopisthus parvipinnis	20,5
Diplobatis sp.	0,9	Cynoscion virescens	179,7
Arius sp.	149,7	Micropogon furnieri	14,9
Bagre bagre	46,8	Stellifer rastrifer	19,6
Odonthognathus mucronatus	1,8	Nebris microps	13,1
Harengula sp.	3,7	Paralonchurus elegans	4,6
Anchoa spinifer	33,6	Trichiurus lepturus (juv.)	4,6
Macrodon ancylodon	149,7	Camarones	56,1

Peso Muestra (kg): 39,20; Total de la Calada (kg): 734

Arrastre 22

Expedición: LS-38-P   Fecha: 10-7-68   Horas: 10.00 - 12.00

Latitud: 06°18' - 06°22,5'   Longitud: 54°42' - 54°49'   Profundidad: 10-13 Br.

Total de la Calada (kg) 1 078

Observaciones: Misma composición que el arrastre 21. Caranx hippos (1) grande - Chetodipterus faber (1) grande. Carcharhinus limbatus 1,75 m, 40 kg (1) y (1) de 1,50 m, 23 kg.

Arrastre 25

Expedición: LS-38-P   Fecha: 11-7-68   Horas: 05.10 - 07.10

Latitud: 06°12' - 06°12'   Longitud: 55°12' - 55°19'   Profundidad: 7-8 Br.

Especies	Total kg	Especies	Total kg
Carcharhinus porosus		Nebris microps	
Sphyrna tudes		Paralonchurus elegans	
Dasyatis guttata		Polyclemus brasiliensis	18,8
Narcine brasiliensis		Isopisthus parvipinnis	47,9
Diplobatis sp.		Larimus breviceps (1)	11,9
Arius spp.	383,9	Micropogon furnieri	34,2
Bagre bagre	17,1	Genyatremus luteus	6,8
Pellona harroweri (gr.)	13,7	Vomer setapinnis	
Odonthognathus mucronatus (4)	6,8	Peprilus paru	
Anchoa spinifer	27,4	Achirus sp.	
Macrodon ancylodon	137,1	Batrachoides surinamensis	8,5
Cynoscion virescens	342,8	Colomesus psittacus (1)	13,7
Stellifer rastrifer		Chylomicterus antillarum (1)	
Stellifer stellifer	143,9		
Stellifer brasiliensis	58,2	Camarones	51,4

Peso Muestra (kg): 38,65; Total de la Calada (kg): 1 325

4.43

APENDICE II

MAPAS CON LOS RESULTADOS DE LOS ARRASTRES POR AREAS

Fig. 1	Sub-áreas estudiadas
Figs 2-12	Resultados del sub-área de Anzoategui
Figs 13-28	Resultados del sub-área de Margarita - Costa Firme
Figs 29-33	Resultados del sub-área de Paria - Boca del Drago
Figs 34-38	Resultados del sub-área de Guayanas

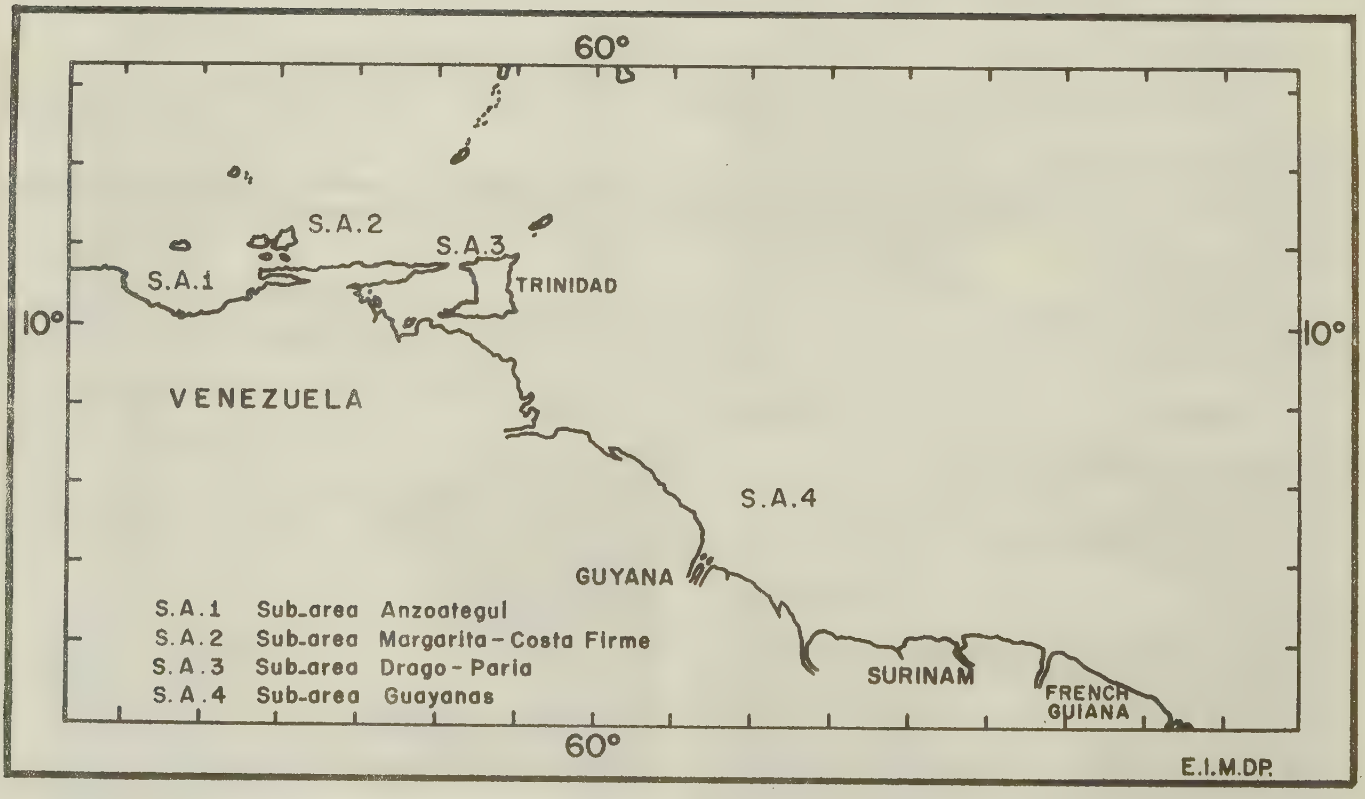

60°
S.A.2
S.A.3
S.A.1
TRINIDAD
10°
10°
VENEZUELA
S.A.4
GUYANA
SURINAM
FRENCH GUIANA
S.A.1 Sub_area Anzoategui
S.A.2 Sub_area Margarita - Costa Firme
S.A.3 Sub_area Drago - Paria
S.A.4 Sub_area Guayanas
60°
E.I.M.DP.

Fig. 1

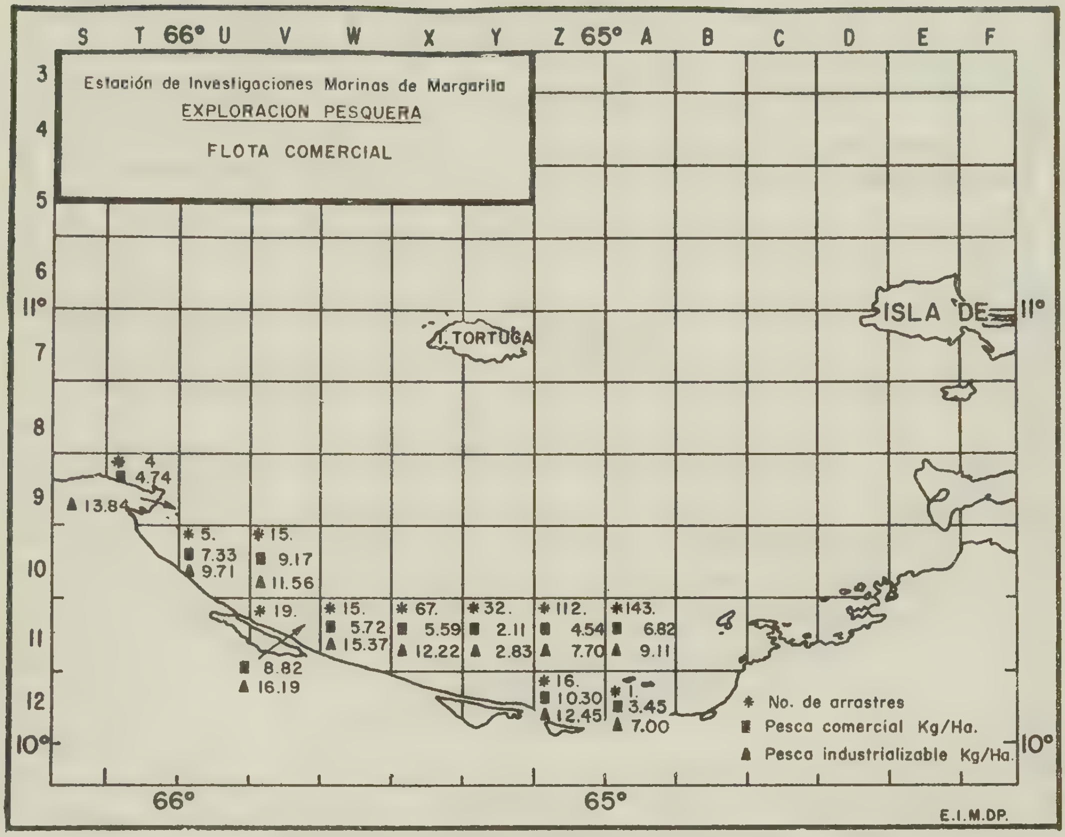

S T 66° U V W X Y Z 65° A B C D E F
3 4 5 6 11° 7 8 9 10 11 12 10°
Estación de Investigaciones Marinas de Margarita
EXPLORACION PESQUERA
FLOTA COMERCIAL
I. TORTUGA
ISLA DE
* 4 ■ 4.74 ▲ 13.84
* 5. ■ 7.33 ▲ 9.71
* 15. ■ 9.17 ▲ 11.56
* 19. ■ 8.82 ▲ 16.19
* 15. ■ 5.72 ▲ 15.37
* 67. ■ 5.59 ▲ 12.22
* 32. ■ 2.11 ▲ 2.83
* 112. ■ 4.54 ▲ 7.70
* 143. ■ 6.82 ▲ 9.11
* 16. ■ 10.30 ▲ 12.45
* 1. ■ 3.45 ▲ 7.00
* No. de arrastres
■ Pesca comercial Kg/Ha.
▲ Pesca industrializable Kg/Ha.
66° 65°
E.I.M.DP.

Fig. 2

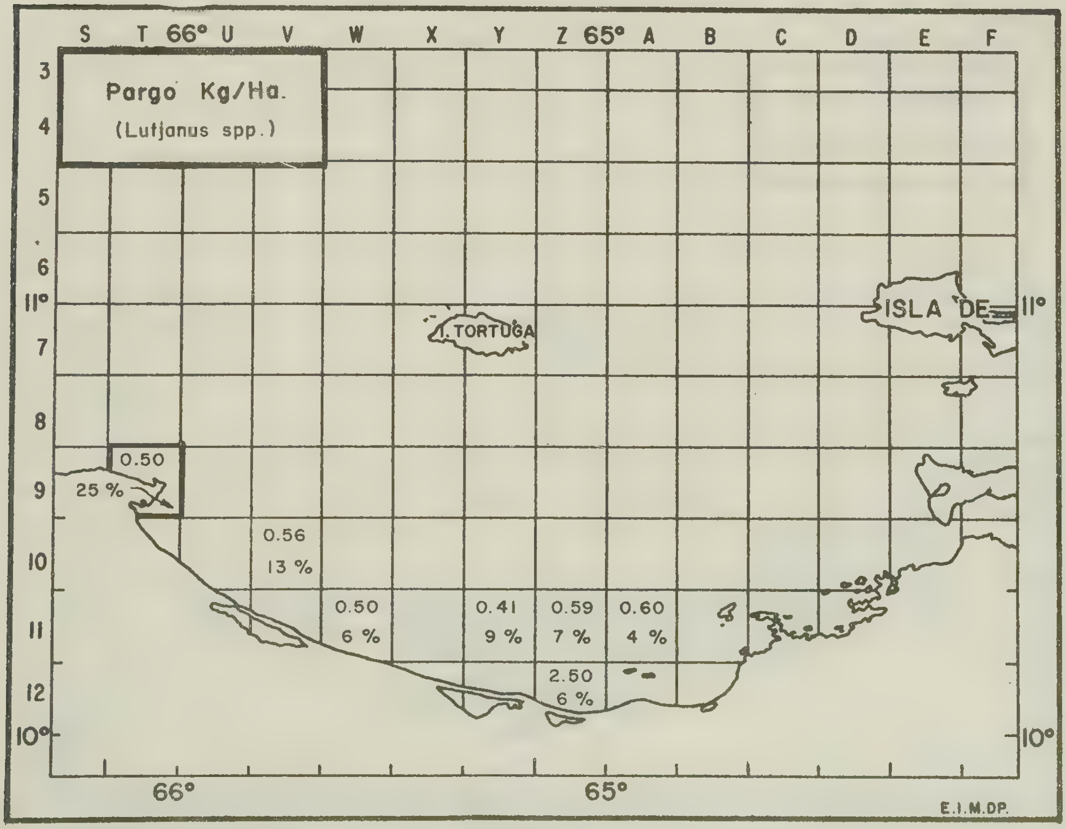

S T 66° U V W X Y Z 65° A B C D E F
3 4 5 6 11° 7 8 9 10 11 12 10°
Pargo Kg/Ha.
(Lutjanus spp.)
I. TORTUGA
ISLA DE
0.50 25 %
0.56 13 %
0.50 6 %
0.41 9 %
0.59 7 %
0.60 4 %
2.50 6 %
66° 65°
E.I.M.DP.

Fig. 3

4.43

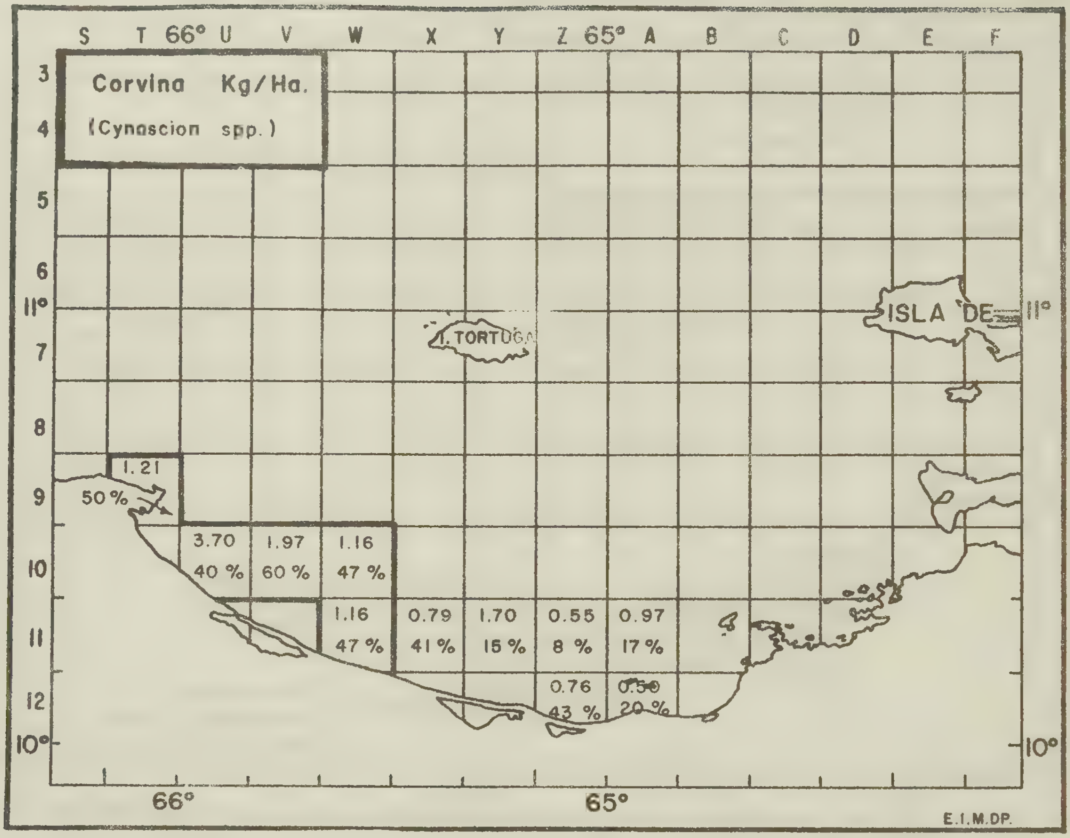

Corvina Kg/Ha.
(Cynoscion spp.)
S
T
66°
U
V
W
X
Y
Z
65°
A
B
C
D
E
F
3
4
5
6
11°
7
8
9
10
11
12
10°
I. TORTUGA
ISLA DE
1.21
50 %
3.70
40 %
1.97
60 %
1.16
47 %
1.16
47 %
0.79
41 %
1.70
15 %
0.55
8 %
0.97
17 %
0.76
43 %
~~0.50~~
20 %
66°
65°
E.I.M.DP.

Fig. 4

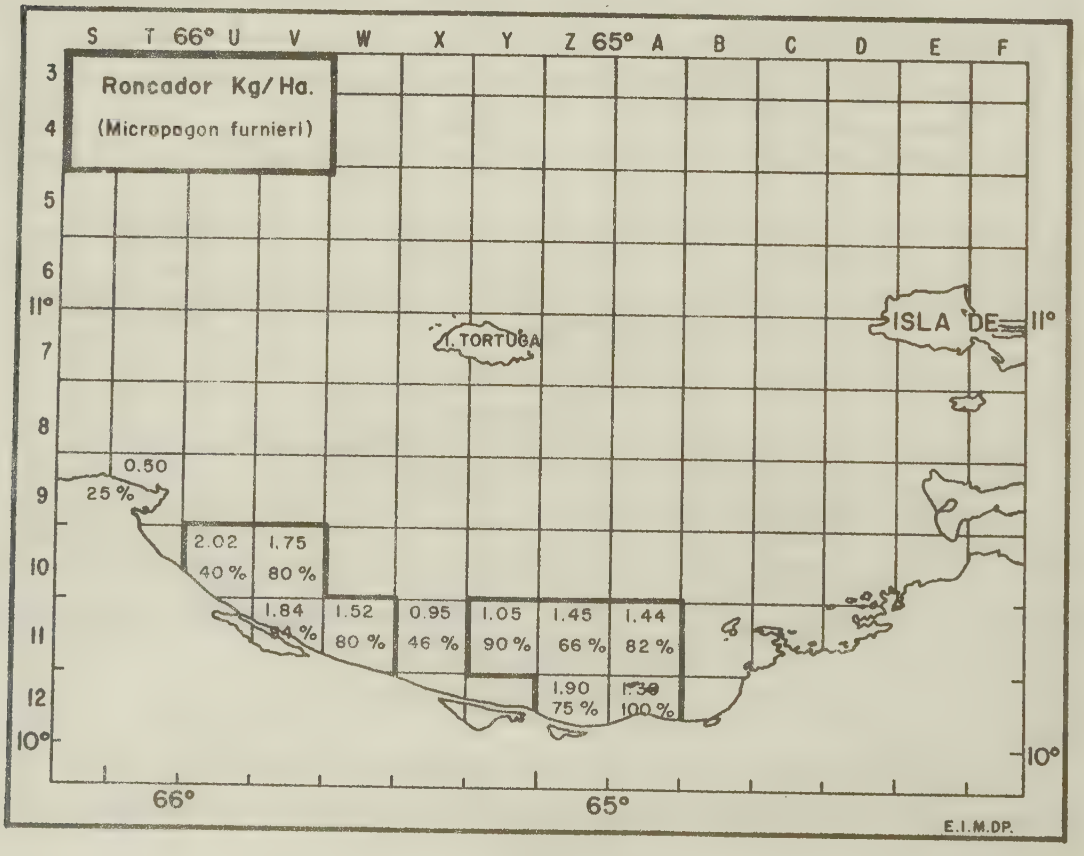

Roncador Kg/Ha.
(Micropogon furnieri)
S
T
66°
U
V
W
X
Y
Z
65°
A
B
C
D
E
F
3
4
5
6
11°
7
8
9
10
11
12
10°
I. TORTUGA
ISLA DE
0.50
25 %
2.02
40 %
1.75
80 %
1.84
84 %
1.52
80 %
0.95
46 %
1.05
90 %
1.45
66 %
1.44
82 %
1.90
75 %
~~1.30~~
100 %
66°
65°
E.I.M.DP.

Fig. 5

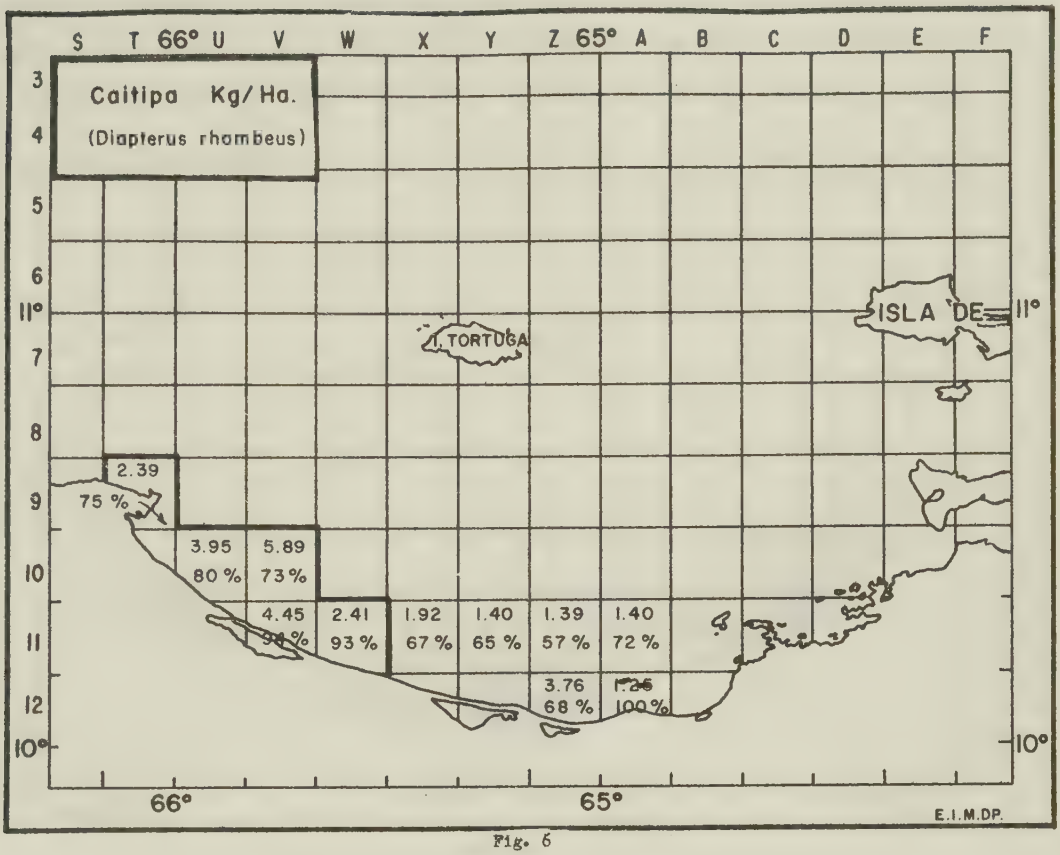

S T 66° U V W X Y Z 65° A B C D E F
3 4 5 6 11° 7 8 9 10 11 12 10°
Caitipa Kg/Ha.
(Diapterus rhombeus)
I. TORTUGA
ISLA DE
11°
2.39
75 %
3.95
80 %
5.89
73 %
4.45
94 %
2.41
93 %
1.92
67 %
1.40
65 %
1.39
57 %
1.40
72 %
3.76
68 %
1.25
100 %
10°
66°
65°
E.I.M.DP.

Fig. 6

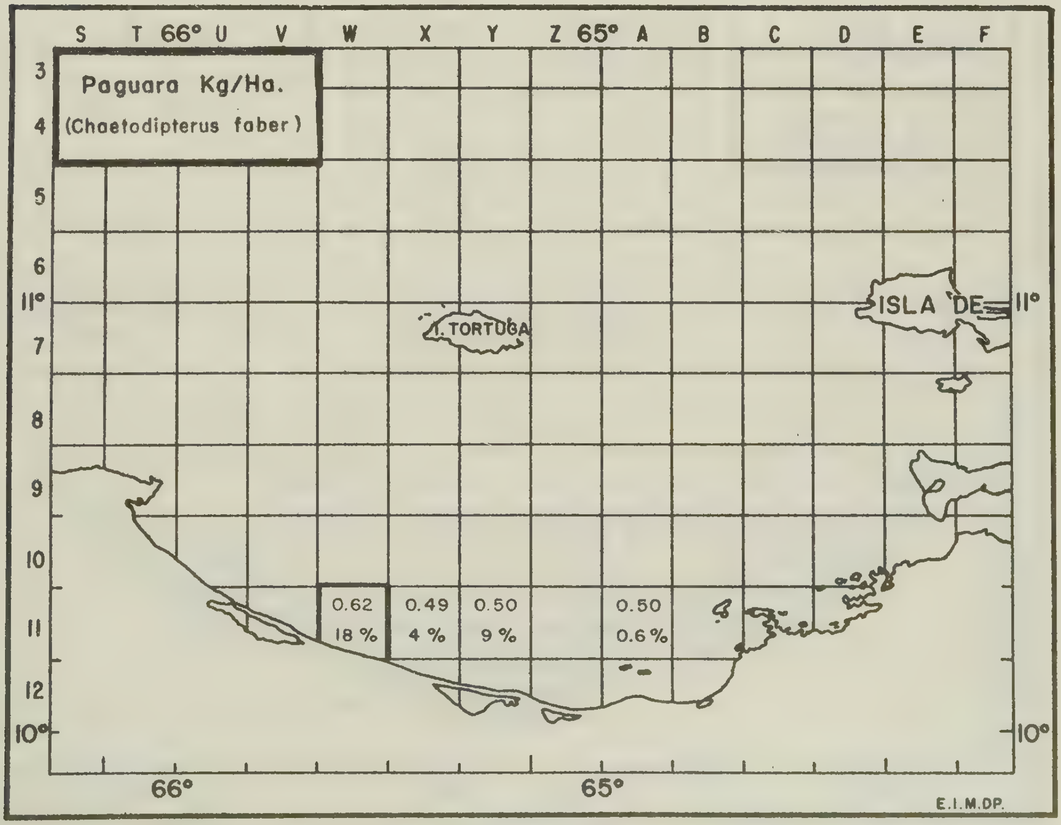

S T 66° U V W X Y Z 65° A B C D E F
3 4 5 6 11° 7 8 9 10 11 12 10°
Paguara Kg/Ha.
(Chaetodipterus faber)
I. TORTUGA
ISLA DE
11°
0.62
18 %
0.49
4 %
0.50
9 %
0.50
0.6 %
10°
66°
65°
E.I.M.DP.

Fig. 7

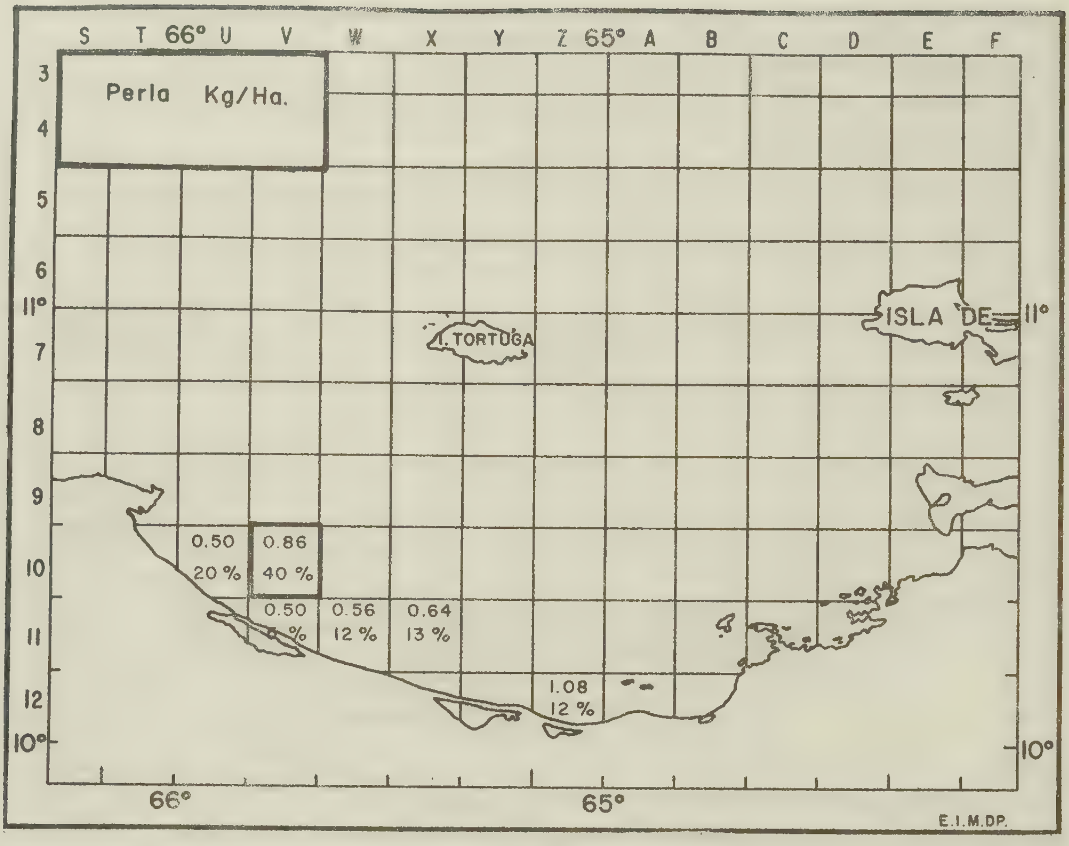

S
T
66°
U
V
W
X
Y
Z
65°
A
B
C
D
E
F
3
4
5
6
11°
7
8
9
10
11
12
10°
Perla Kg/Ha.
I. TORTUGA
ISLA DE
0.50
20 %
0.86
40 %
0.50
%
0.56
12 %
0.64
13 %
1.08
12 %
66°
65°
E.I.M.DP.

Fig. 8

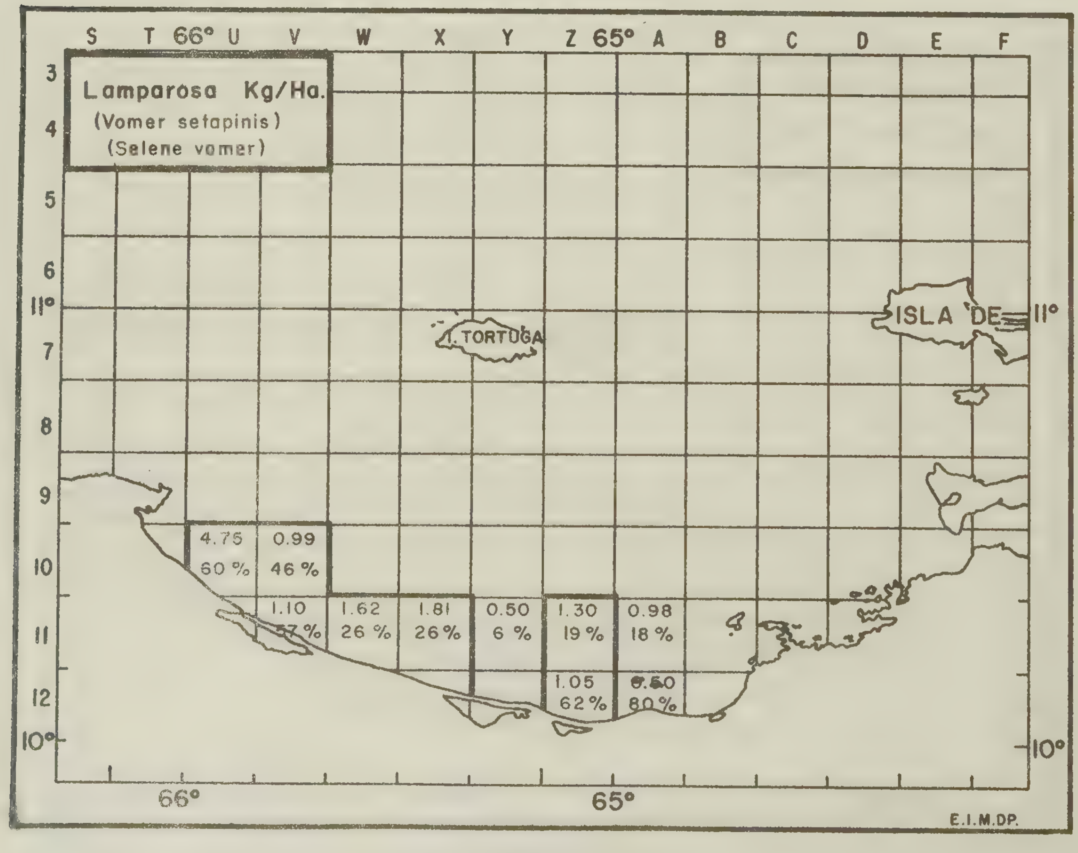

S
T
66°
U
V
W
X
Y
Z
65°
A
B
C
D
E
F
3
4
5
6
11°
7
8
9
10
11
12
10°
Lamparosa Kg/Ha.
(Vomer setapinis)
(Selene vomer)
I. TORTUGA
ISLA DE
4.75
60 %
0.99
46 %
1.10
57 %
1.62
26 %
1.81
26 %
0.50
6 %
1.30
19 %
0.98
18 %
1.05
62 %
0.50
80 %
66°
65°
E.I.M.DP.

Fig. 9

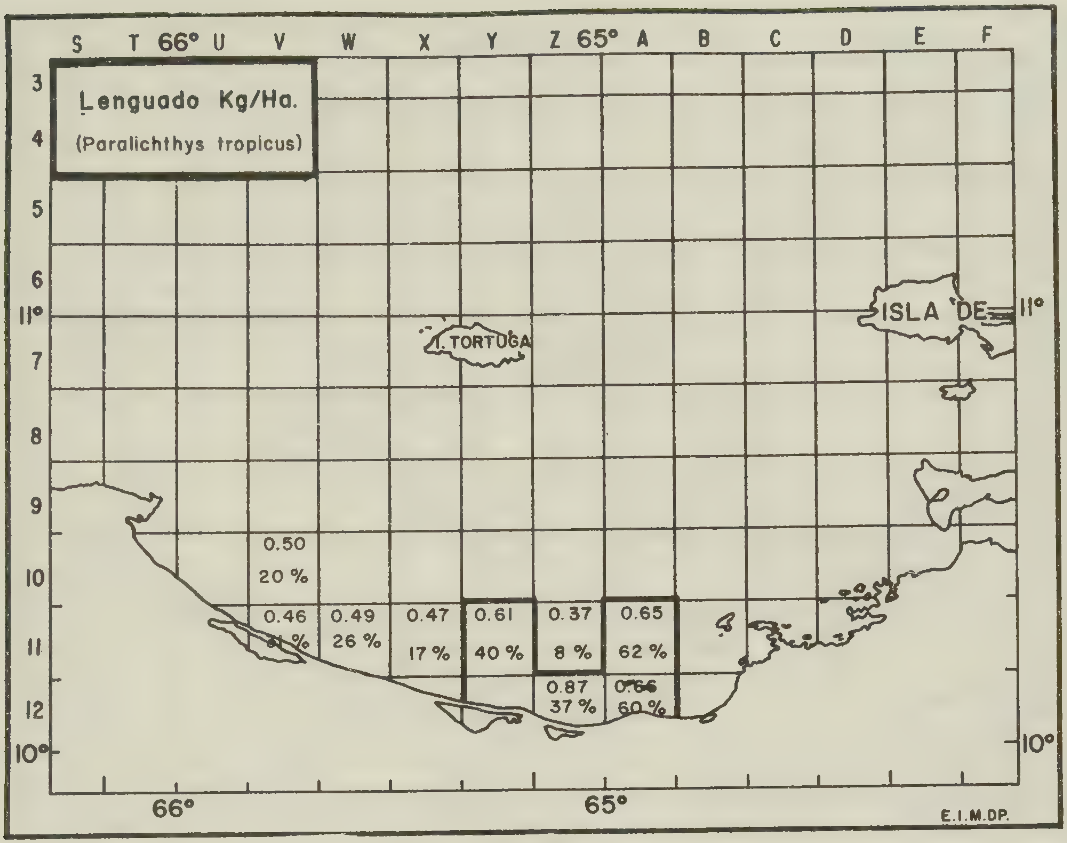

S
T
66°
U
V
W
X
Y
Z
65°
A
B
C
D
E
F
3
4
5
6
11°
7
8
9
10
11
12
10°
Lenguado Kg/Ha.
(Paralichthys tropicus)
I. TORTUGA
ISLA DE
0.50
20 %
0.46
41 %
0.49
26 %
0.47
17 %
0.61
40 %
0.37
8 %
0.65
62 %
0.87
37 %
0.66
60 %
66°
65°
E.I.M.DP.

Fig. 10

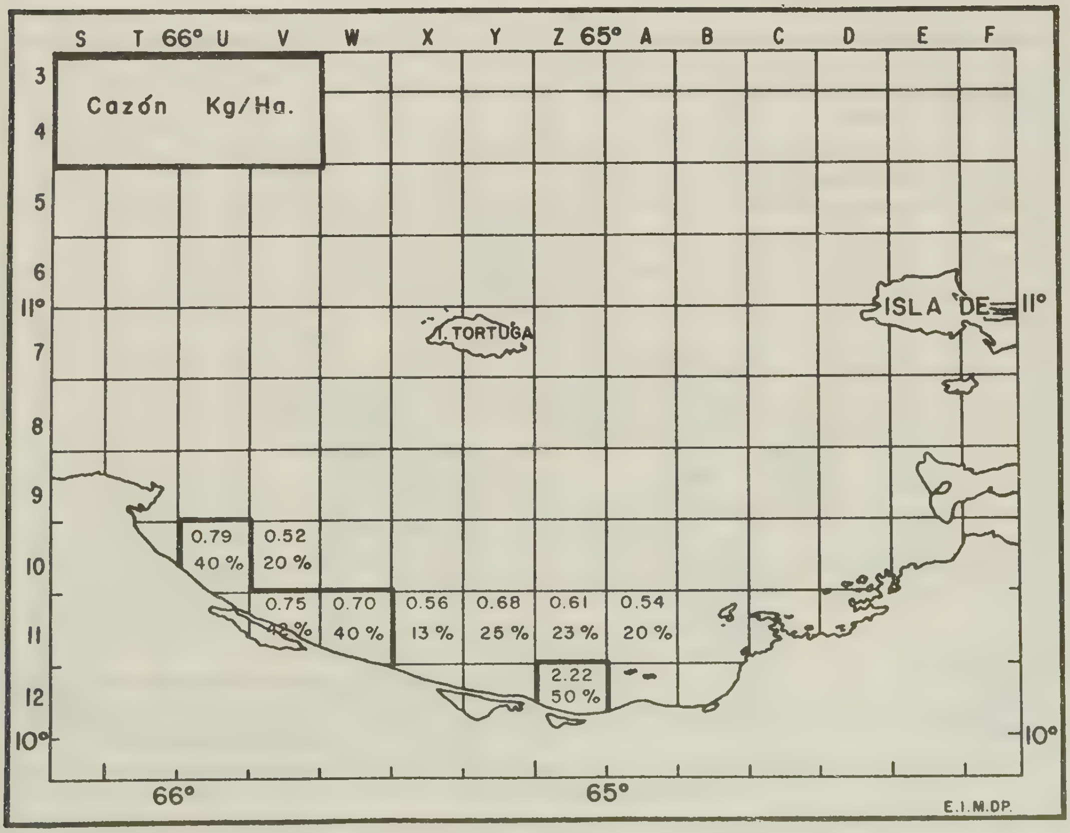

S
T
66°
U
V
W
X
Y
Z
65°
A
B
C
D
E
F
3
4
5
6
11°
7
8
9
10
11
12
10°
Cazón Kg/Ha.
I. TORTUGA
ISLA DE
0.79
40 %
0.52
20 %
0.75
42 %
0.70
40 %
0.56
13 %
0.68
25 %
0.61
23 %
0.54
20 %
2.22
50 %
66°
65°
E.I.M.DP.

Fig. 11

4.43

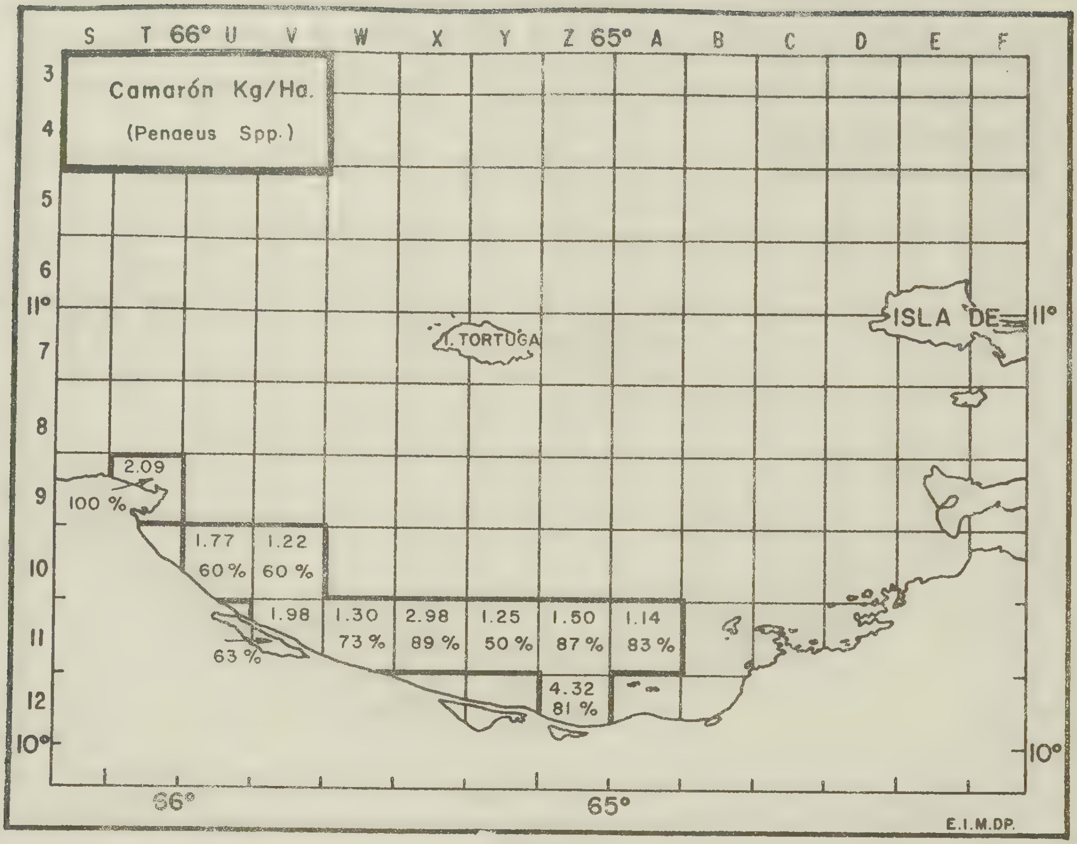

S T 66° U V W X Y Z 65° A B C D E F
3
4
5
6
11°
7
8
9
10
11
12
10°
Camarón Kg/Ha.
(Penaeus Spp.)
I. TORTUGA
ISLA DE
2.09
100 %
1.77
60 %
1.22
60 %
1.98
63 %
1.30
73 %
2.98
89 %
1.25
50 %
1.50
87 %
1.14
83 %
4.32
81 %
66°
65°
E.I.M.DP.

Fig. 12

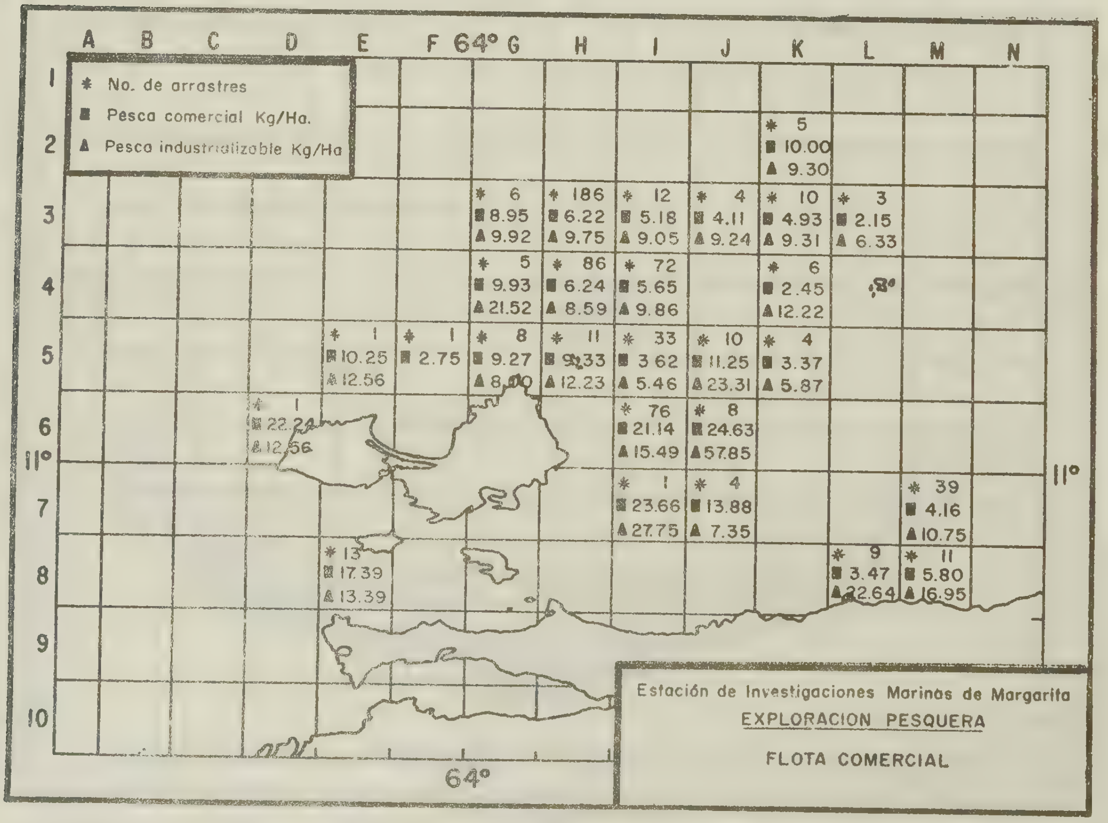

A B C D E F 64° G H I J K L M N
1
2
3
4
5
6
11°
7
8
9
10
* No. de arrastres
■ Pesca comercial Kg/Ha.
▲ Pesca industrializable Kg/Ha
* 5
■ 10.00
▲ 9.30
* 6
■ 8.95
▲ 9.92
* 186
■ 6.22
▲ 9.75
* 12
■ 5.18
▲ 9.05
* 4
■ 4.11
▲ 9.24
* 10
■ 4.93
▲ 9.31
* 3
■ 2.15
▲ 6.33
* 5
■ 9.93
▲ 21.52
* 86
■ 6.24
▲ 8.59
* 72
■ 5.65
▲ 9.86
* 6
■ 2.45
▲ 12.22
* 1
■ 10.25
▲ 12.56
* 1
■ 2.75
* 8
■ 9.27
▲ 8.00
* 11
■ 9.33
▲ 12.23
* 33
■ 3.62
▲ 5.46
* 10
■ 11.25
▲ 23.31
* 4
■ 3.37
▲ 5.87
* 1
■ 22.24
▲ 12.56
* 76
■ 21.14
▲ 15.49
* 8
■ 24.63
▲ 57.85
* 1
■ 23.66
▲ 27.75
* 4
■ 13.88
▲ 7.35
* 39
■ 4.16
▲ 10.75
* 13
■ 17.39
▲ 13.39
* 9
■ 3.47
▲ 22.64
* 11
■ 5.80
▲ 16.95
11°
64°
Estación de Investigaciones Marinas de Margarita
EXPLORACION PESQUERA
FLOTA COMERCIAL

Fig. 13

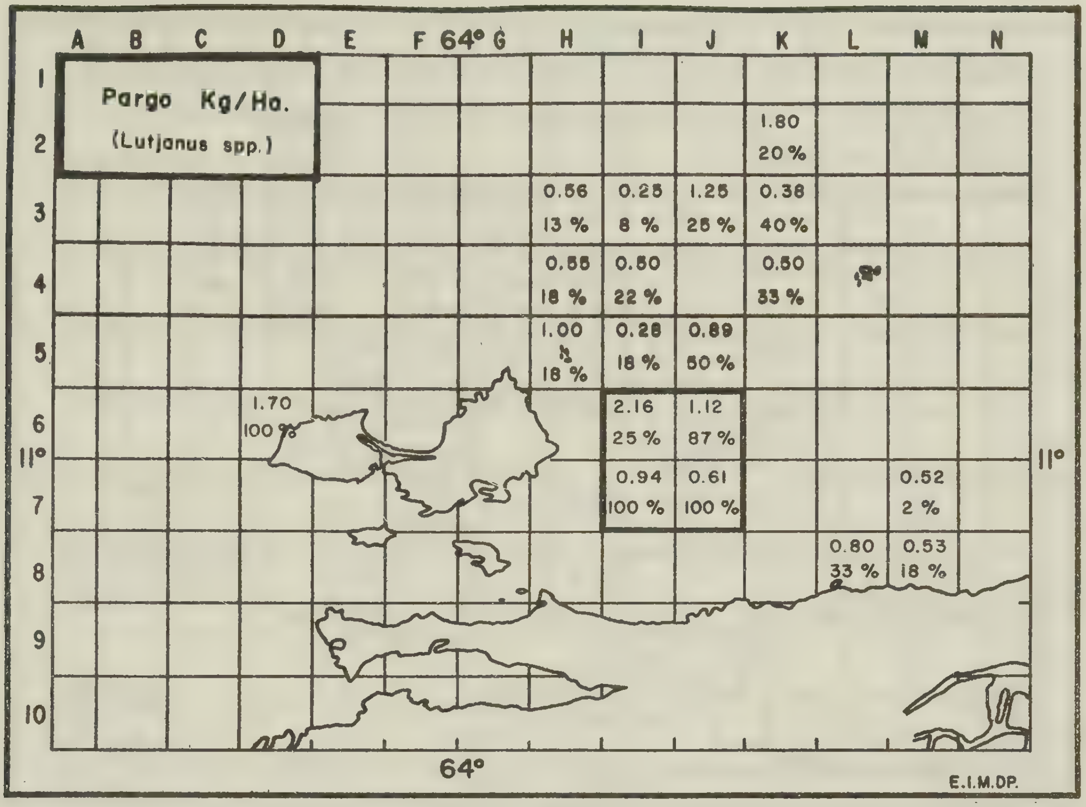

Pargo Kg/Ha.
(Lutjanus spp.)
A B C D E F 64° G H I J K L M N
1 2 3 4 5 6 7 8 9 10
11°
1.80 20 %
0.56 13 %
0.25 8 %
1.25 25 %
0.38 40 %
0.55 18 %
0.50 22 %
0.50 33 %
1.00 18 %
0.28 18 %
0.89 50 %
1.70 100 %
2.16 25 %
1.12 87 %
0.94 100 %
0.61 100 %
0.52 2 %
0.80 33 %
0.53 18 %
64°
E.I.M.DP.

Fig. 14

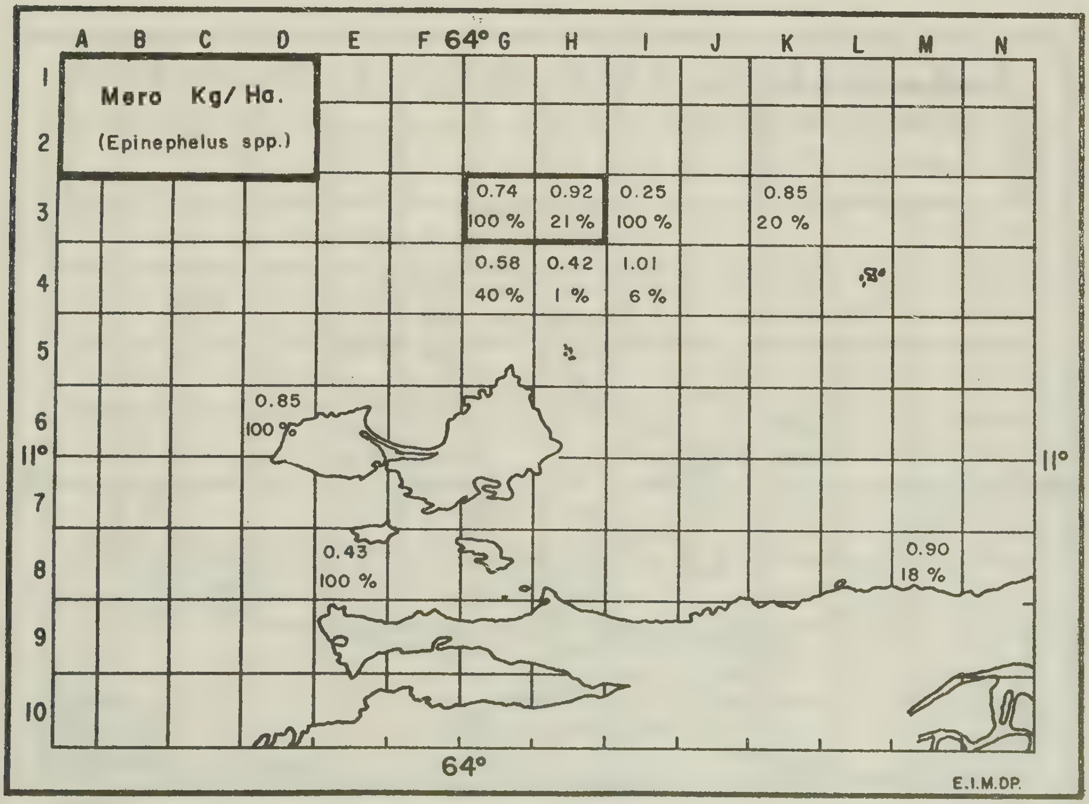

Mero Kg/Ha.
(Epinephelus spp.)
A B C D E F 64° G H I J K L M N
1 2 3 4 5 6 7 8 9 10
11°
0.74 100 %
0.92 21 %
0.25 100 %
0.85 20 %
0.58 40 %
0.42 1 %
1.01 6 %
0.85 100 %
0.43 100 %
0.90 18 %
64°
E.I.M.DP.

Fig. 15

4.43

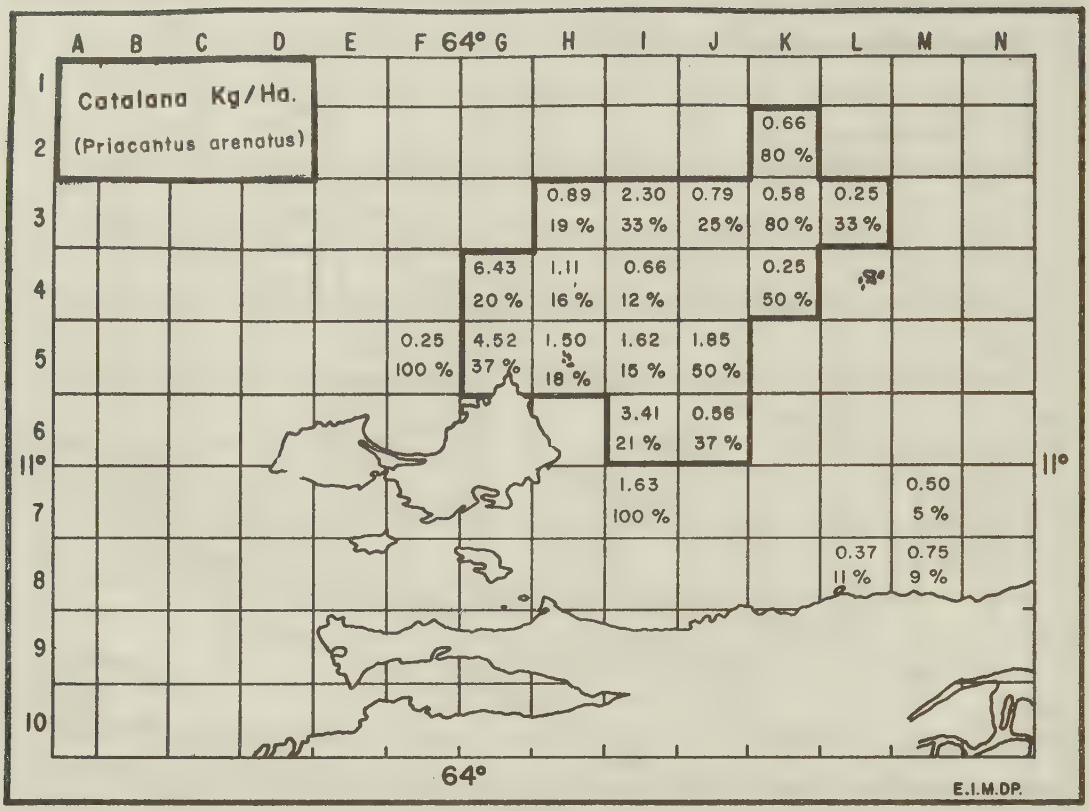

A B C D E F 64° G H I J K L M N
1 2 3 4 5 6 7 8 9 10
Catalana Kg/Ha.
(Priacantus arenatus)
0.66 80 %
0.89 19 %
2.30 33 %
0.79 25 %
0.58 80 %
0.25 33 %
6.43 20 %
1.11 16 %
0.66 12 %
0.25 50 %
0.25 100 %
4.52 37 %
1.50 18 %
1.62 15 %
1.85 50 %
3.41 21 %
0.56 37 %
1.63 100 %
0.50 5 %
0.37 11 %
0.75 9 %
11°
11°
64°
E.I.M.DP.

Fig. 16

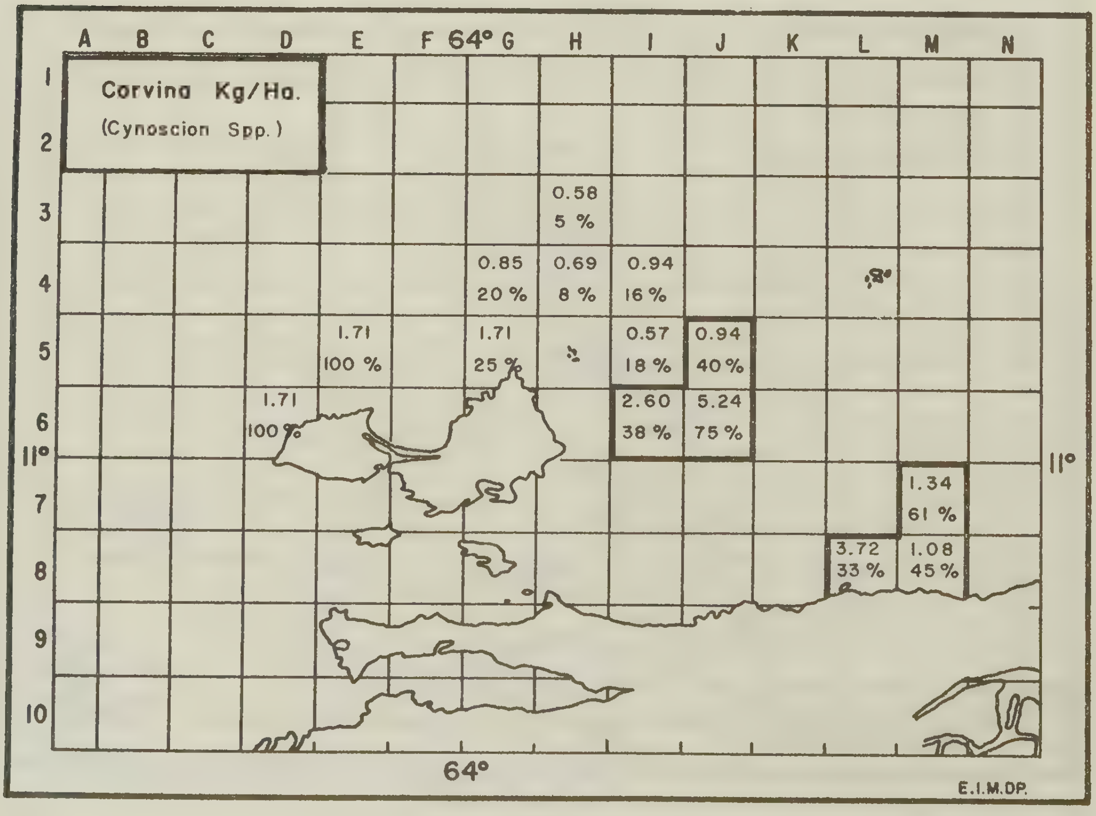

A B C D E F 64° G H I J K L M N
1 2 3 4 5 6 7 8 9 10
Corvina Kg/Ha.
(Cynoscion Spp.)
0.58 5 %
0.85 20 %
0.69 8 %
0.94 16 %
1.71 100 %
1.71 25 %
0.57 18 %
0.94 40 %
1.71 100 %
2.60 38 %
5.24 75 %
1.34 61 %
3.72 33 %
1.08 45 %
11°
11°
64°
E.I.M.DP.

Fig. 17

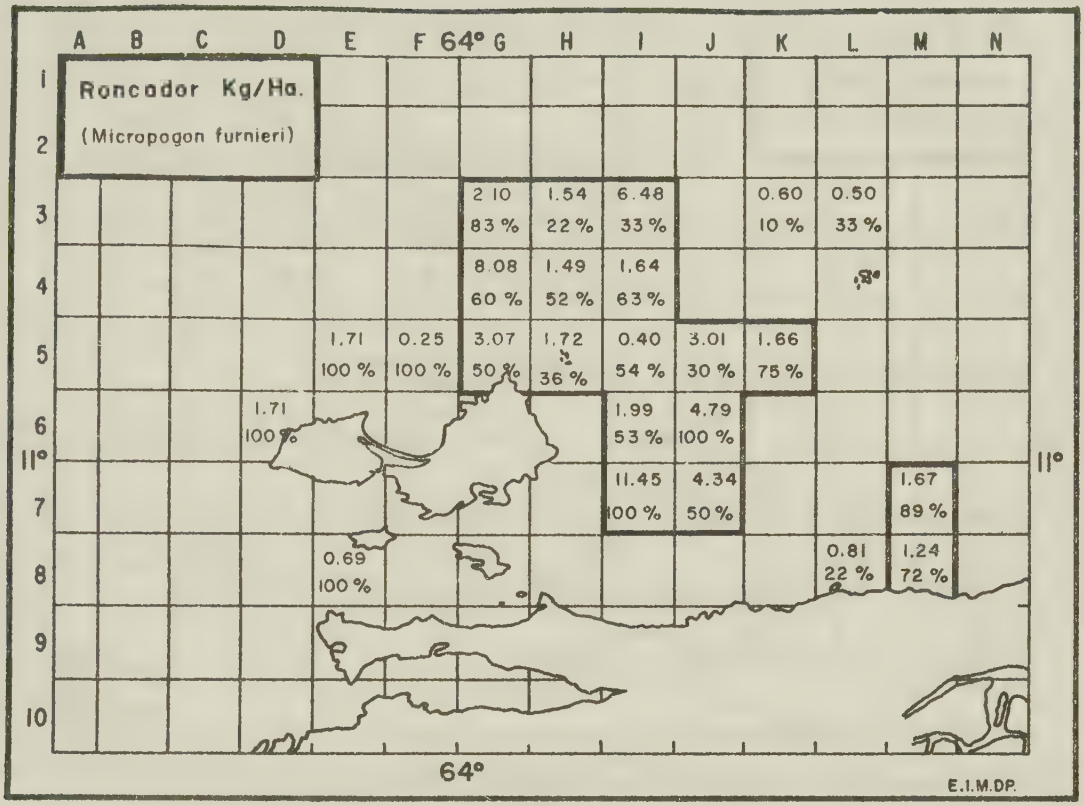

Roncador Kg/Ha.
(Micropogon furnieri)
A B C D E F 64° G H I J K L M N
1 2 3 4 5 6 7 8 9 10
11°
64°
2.10 83 %
1.54 22 %
6.48 33 %
0.60 10 %
0.50 33 %
8.08 60 %
1.49 52 %
1.64 63 %
1.71 100 %
0.25 100 %
3.07 50 %
1.72 36 %
0.40 54 %
3.01 30 %
1.66 75 %
1.71 100 %
1.99 53 %
4.79 100 %
11.45 100 %
4.34 50 %
1.67 89 %
0.69 100 %
0.81 22 %
1.24 72 %
E.I.M.DP.

Fig. 18

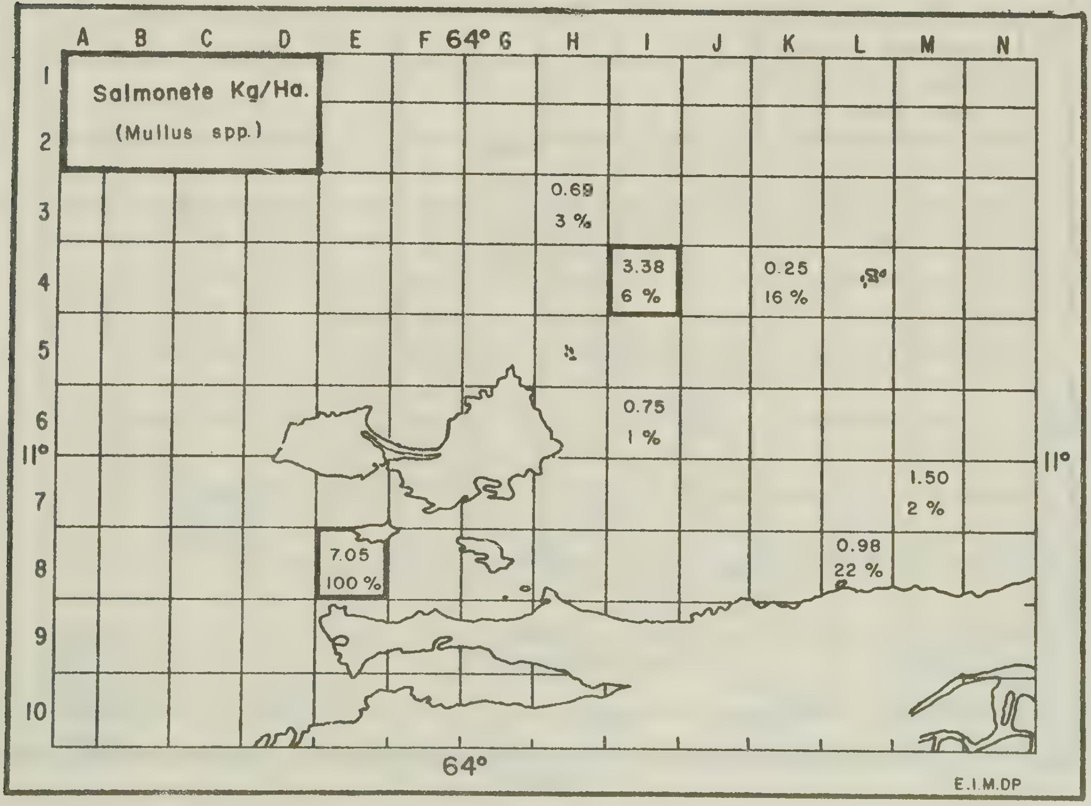

Salmonete Kg/Ha.
(Mullus spp.)
A B C D E F 64° G H I J K L M N
1 2 3 4 5 6 7 8 9 10
11°
64°
0.69 3 %
3.38 6 %
0.25 16 %
0.75 1 %
1.50 2 %
7.05 100 %
0.98 22 %
E.I.M.DP

Fig. 19

4.43

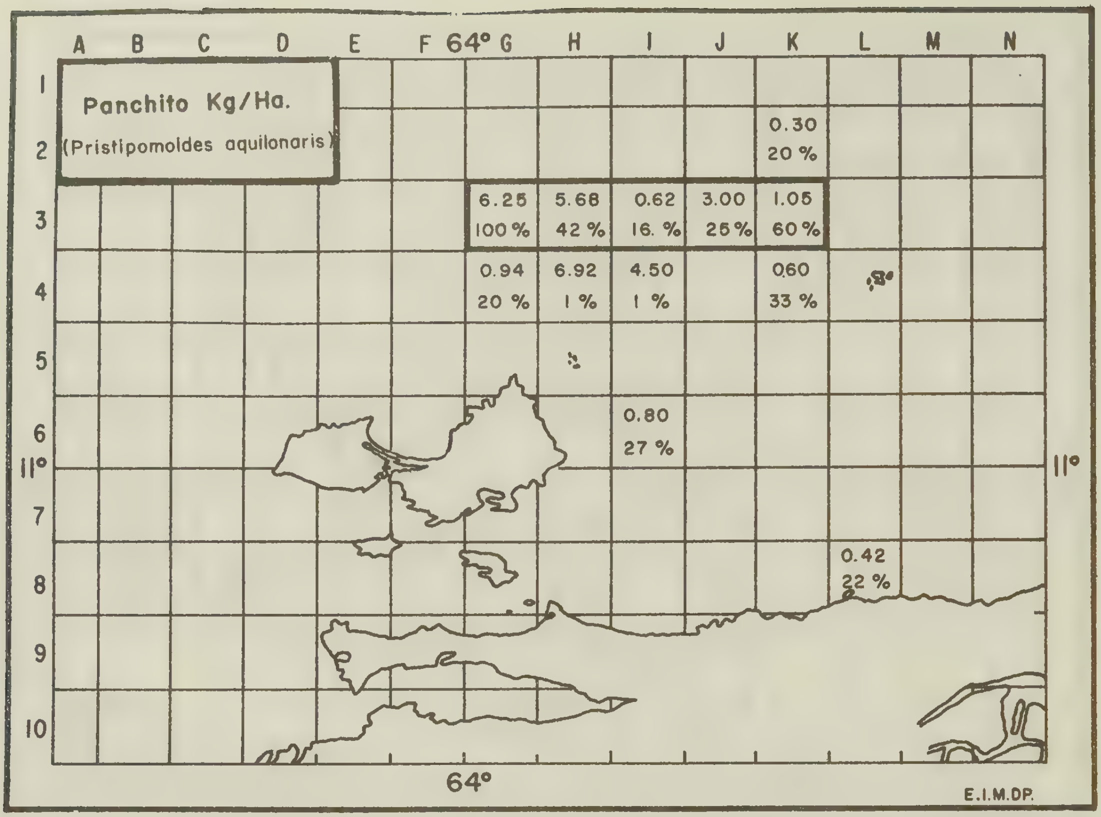

A B C D E F 64° G H I J K L M N
1 2 3 4 5 6 7 8 9 10
Panchito Kg/Ha.
(Pristipomoides aquilonaris)
0.30
20 %
6.25
100 %
5.68
42 %
0.62
16. %
3.00
25 %
1.05
60 %
0.94
20 %
6.92
1 %
4.50
1 %
0.60
33 %
0.80
27 %
11°
0.42
22 %
64°
E.I.M.DP.

Fig. 20

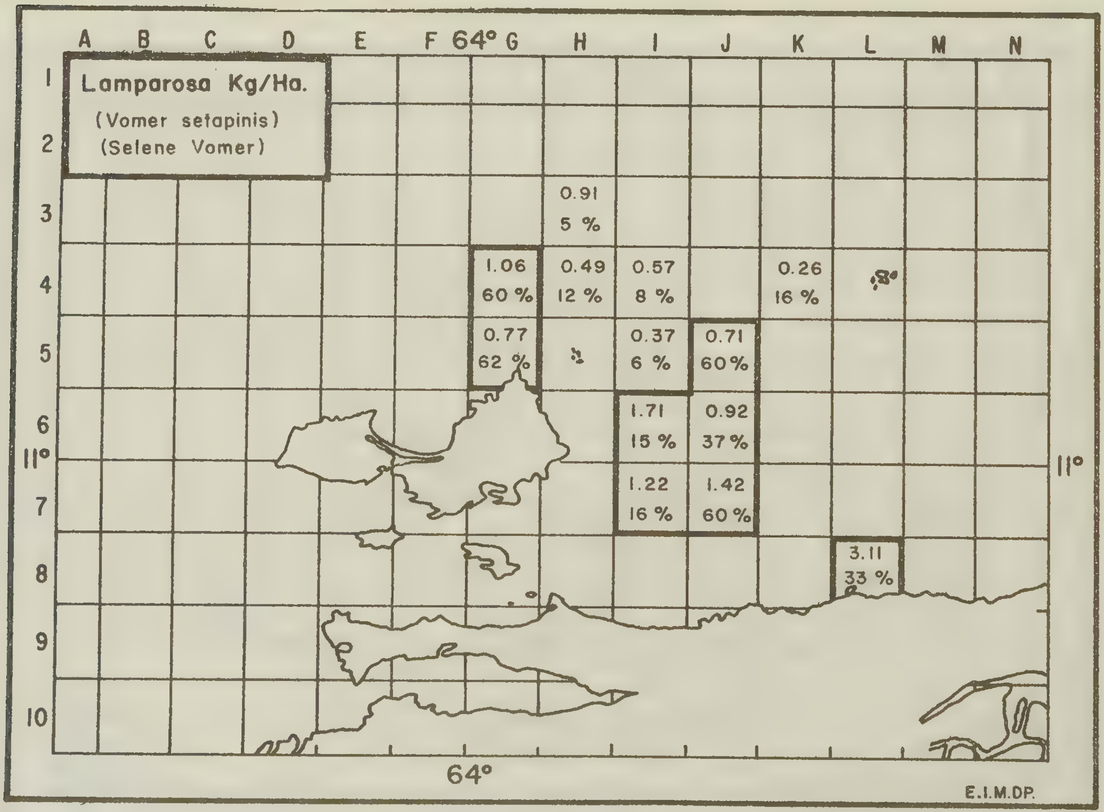

A B C D E F 64° G H I J K L M N
1 2 3 4 5 6 7 8 9 10
Lamparosa Kg/Ha.
(Vomer setapinis)
(Selene Vomer)
0.91
5 %
1.06
60 %
0.49
12 %
0.57
8 %
0.26
16 %
0.77
62 %
0.37
6 %
0.71
60 %
1.71
15 %
0.92
37 %
11°
1.22
16 %
1.42
60 %
3.11
33 %
64°
E.I.M.DP.

Fig. 21

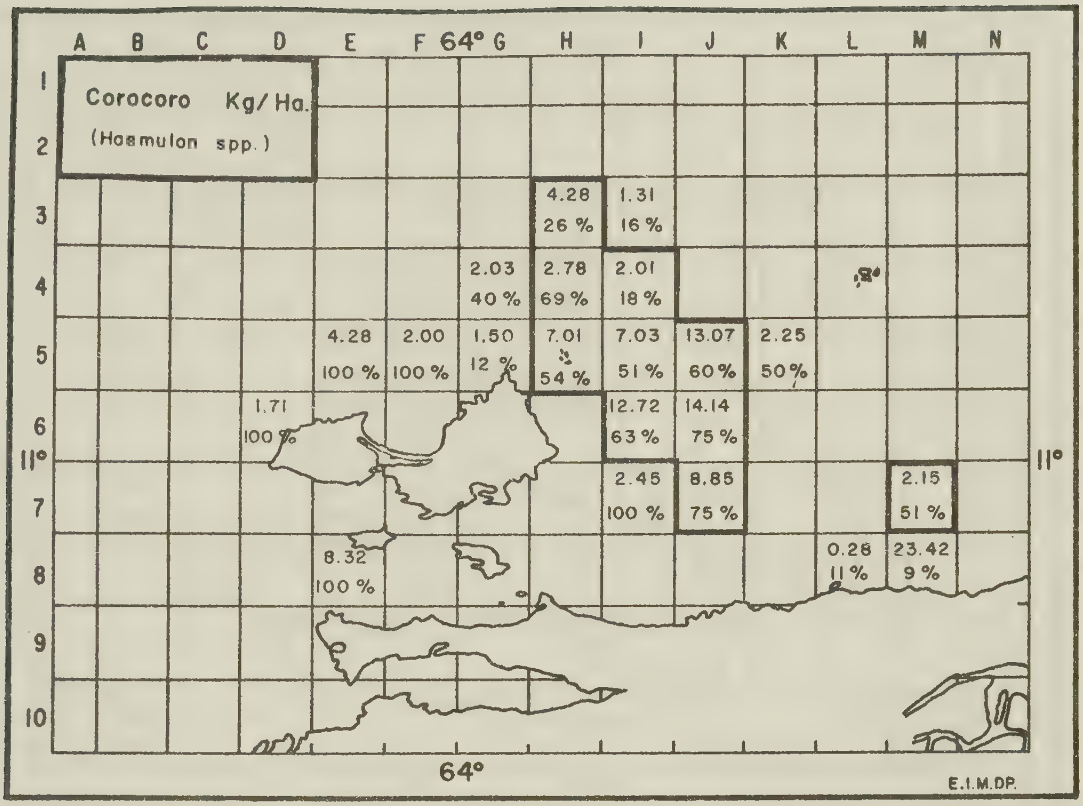

A B C D E F 64° G H I J K L M N
1 2 3 4 5 6 7 8 9 10
Corocoro Kg/Ha.
(Haemulon spp.)
4.28 26 %
1.31 16 %
2.03 40 %
2.78 69 %
2.01 18 %
4.28 100 %
2.00 100 %
1.50 12 %
7.01 54 %
7.03 51 %
13.07 60 %
2.25 50 %
1.71 100 %
12.72 63 %
14.14 75 %
11°
11°
2.45 100 %
8.85 75 %
2.15 51 %
8.32 100 %
0.28 11 %
23.42 9 %
64°
E.I.M.DP.

Fig. 22

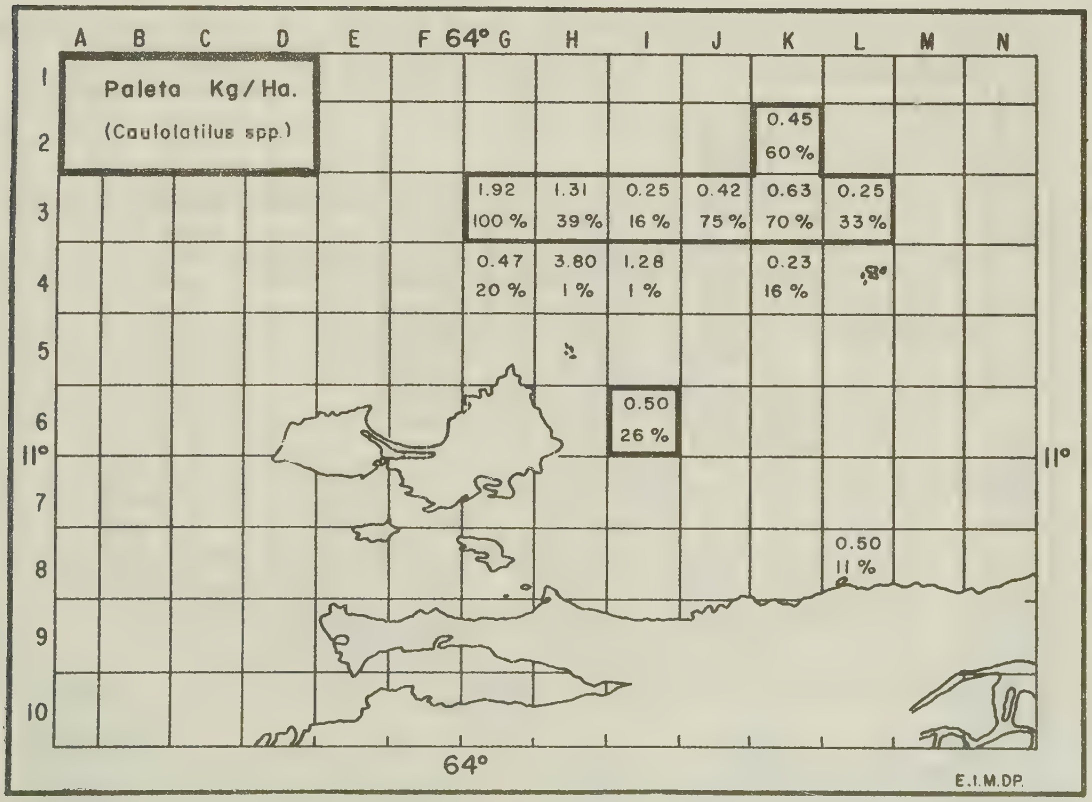

A B C D E F 64° G H I J K L M N
1 2 3 4 5 6 7 8 9 10
Paleta Kg/Ha.
(Caulolatilus spp.)
0.45 60 %
1.92 100 %
1.31 39 %
0.25 16 %
0.42 75 %
0.63 70 %
0.25 33 %
0.47 20 %
3.80 1 %
1.28 1 %
0.23 16 %
0.50 26 %
11°
11°
0.50 11 %
64°
E.I.M.DP.

Fig. 23

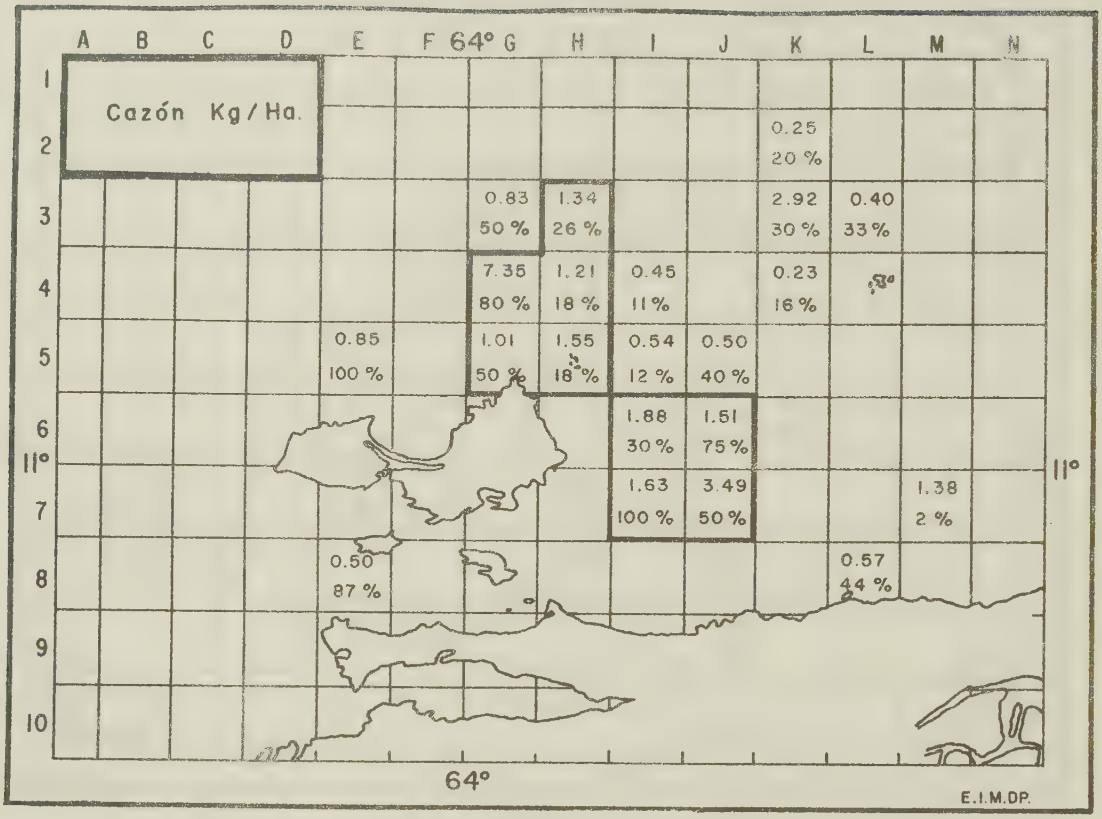

Cazón Kg/Ha.
A B C D E F 64° G H I J K L M N
1 2 3 4 5 6 7 8 9 10
11°
64°
0.25 20 %
0.83 50 %
1.34 26 %
2.92 30 %
0.40 33 %
7.35 80 %
1.21 18 %
0.45 11 %
0.23 16 %
0.85 100 %
1.01 50 %
1.55 18 %
0.54 12 %
0.50 40 %
1.88 30 %
1.51 75 %
1.63 100 %
3.49 50 %
1.38 2 %
0.50 87 %
0.57 44 %
E.I.M.DP.

Fig. 24

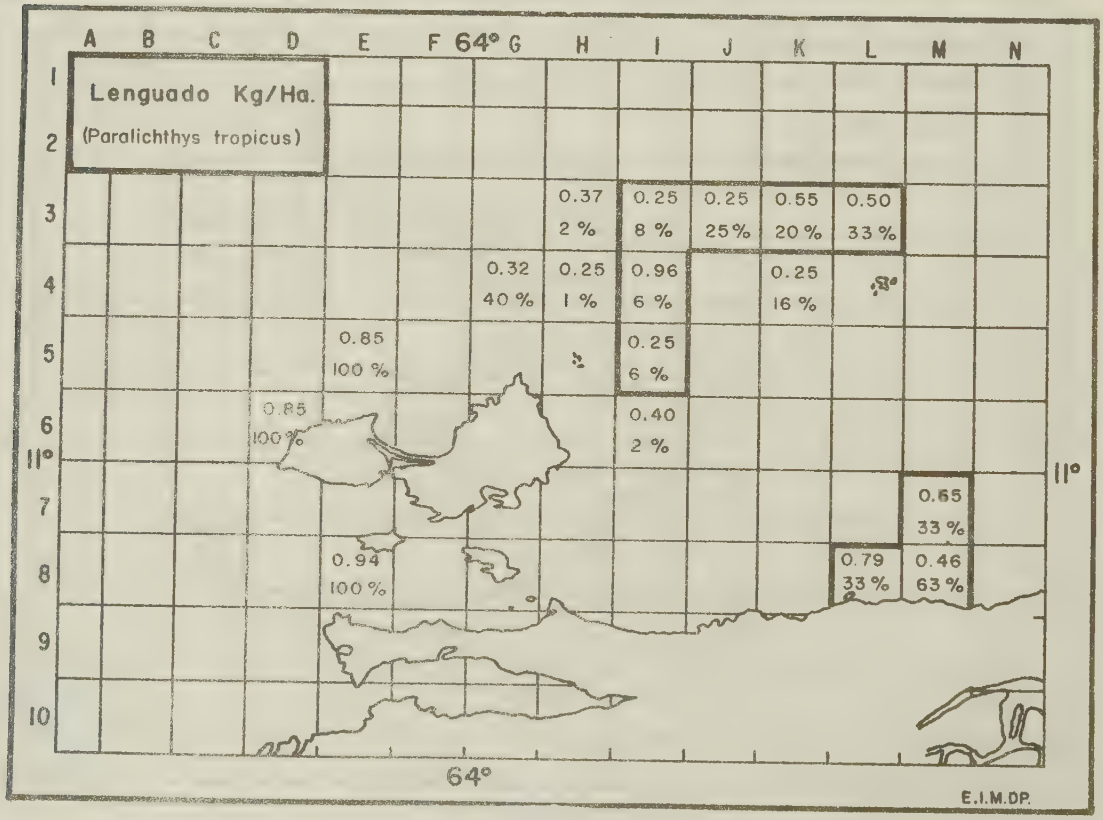

Lenguado Kg/Ha.
(Paralichthys tropicus)
A B C D E F 64° G H I J K L M N
1 2 3 4 5 6 7 8 9 10
11°
64°
0.37 2 %
0.25 8 %
0.25 25 %
0.55 20 %
0.50 33 %
0.32 40 %
0.25 1 %
0.96 6 %
0.25 16 %
0.85 100 %
0.25 6 %
0.85 100 %
0.40 2 %
0.65 33 %
0.94 100 %
0.79 33 %
0.46 63 %
E.I.M.DP.

Fig. 25

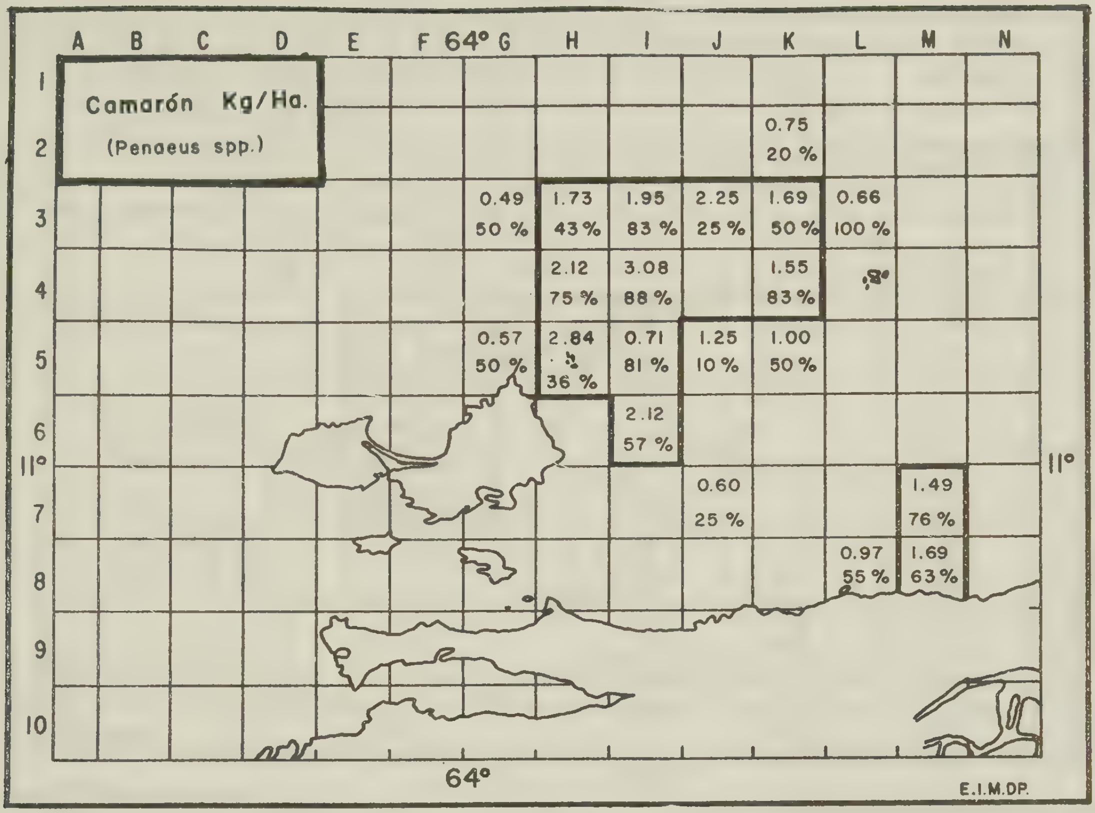

A B C D E F 64° G H I J K L M N
1 2 3 4 5 6 11° 7 8 9 10
Camarón Kg/Ha.
(Penaeus spp.)
0.75 20 %
0.49 50 %
1.73 43 %
1.95 83 %
2.25 25 %
1.69 50 %
0.66 100 %
2.12 75 %
3.08 88 %
1.55 83 %
0.57 50 %
2.84 36 %
0.71 81 %
1.25 10 %
1.00 50 %
2.12 57 %
0.60 25 %
1.49 76 %
0.97 55 %
1.69 63 %
11°
64°
E.I.M.DP.

Fig. 26

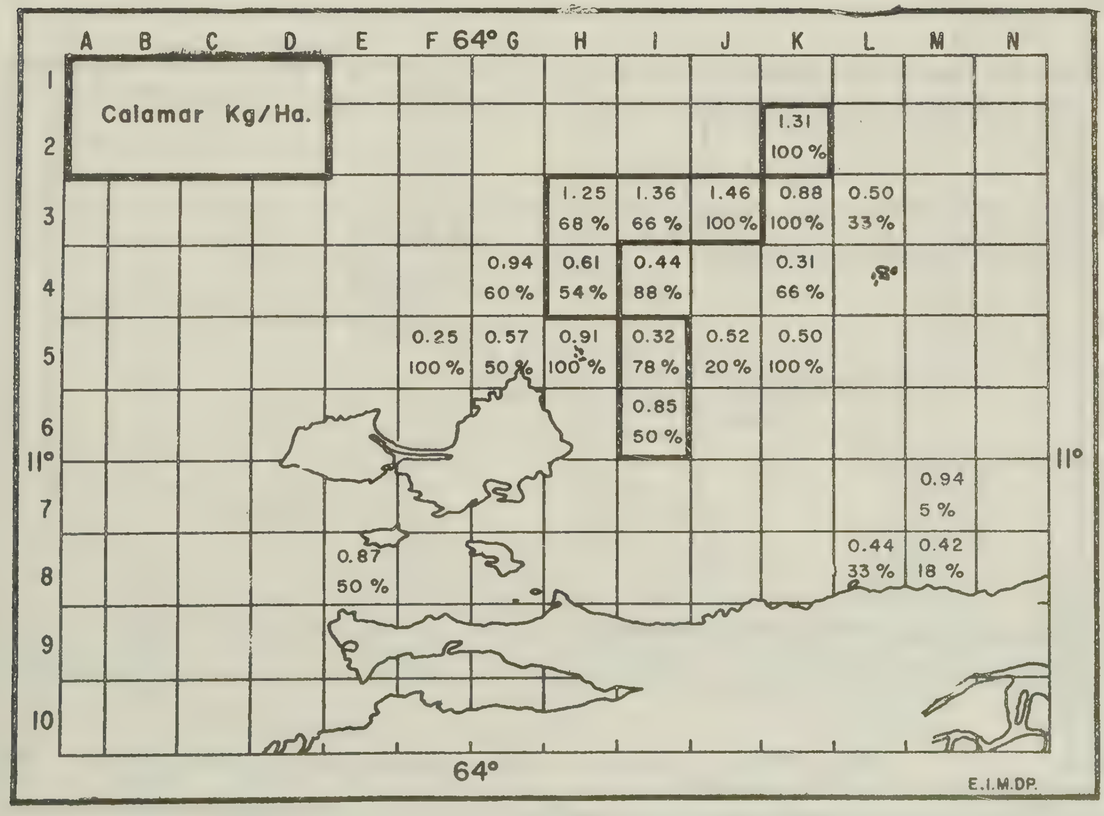

A B C D E F 64° G H I J K L M N
1 2 3 4 5 6 11° 7 8 9 10
Calamar Kg/Ha.
1.31 100 %
1.25 68 %
1.36 66 %
1.46 100 %
0.88 100 %
0.50 33 %
0.94 60 %
0.61 54 %
0.44 88 %
0.31 66 %
0.25 100 %
0.57 50 %
0.91 100 %
0.32 78 %
0.52 20 %
0.50 100 %
0.85 50 %
0.94 5 %
0.87 50 %
0.44 33 %
0.42 18 %
11°
64°
E.I.M.DP.

Fig. 27

4.43

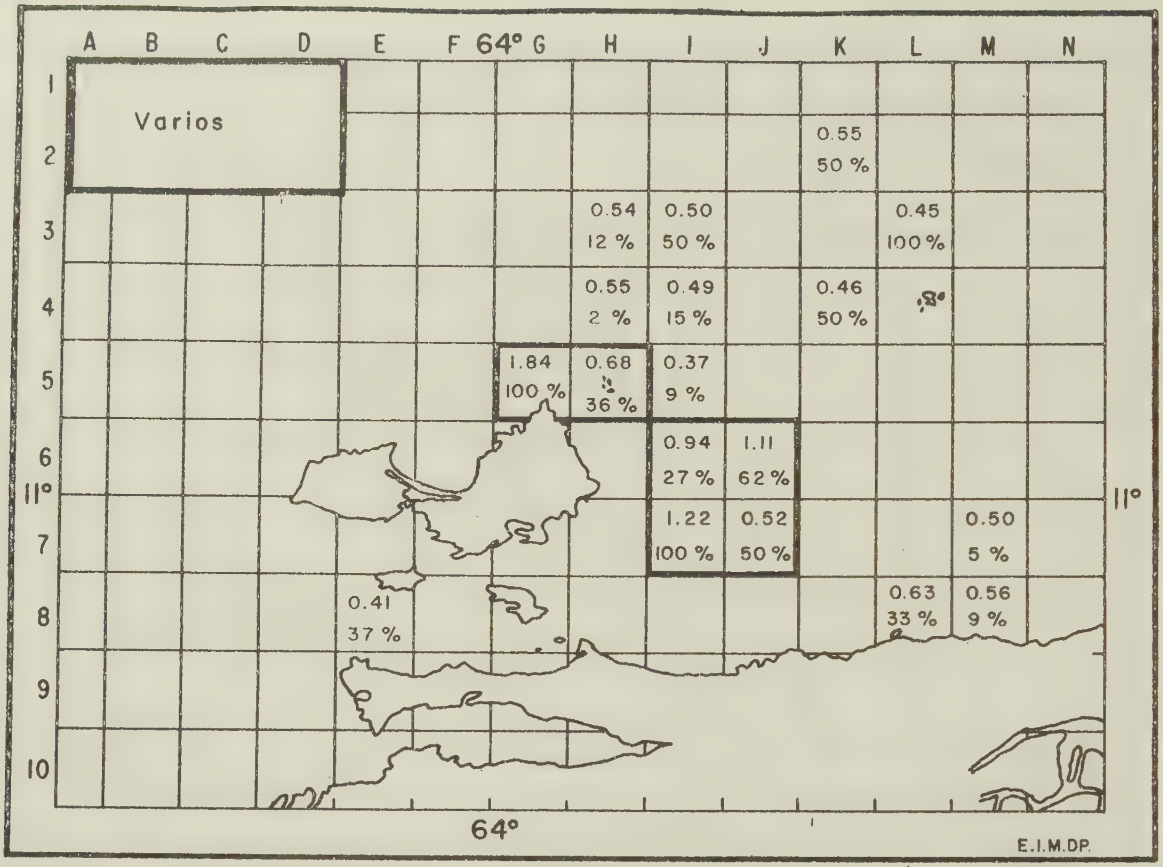

A
B
C
D
E
F
64°
G
H
I
J
K
L
M
N
1
2
3
4
5
6
11°
7
8
9
10
Varios
0.55
50 %
0.54
12 %
0.50
50 %
0.45
100 %
0.55
2 %
0.49
15 %
0.46
50 %
1.84
100 %
0.68
36 %
0.37
9 %
0.94
27 %
1.11
62 %
1.22
100 %
0.52
50 %
0.50
5 %
0.41
37 %
0.63
33 %
0.56
9 %
11°
64°
E.I.M.DP.

Fig. 28

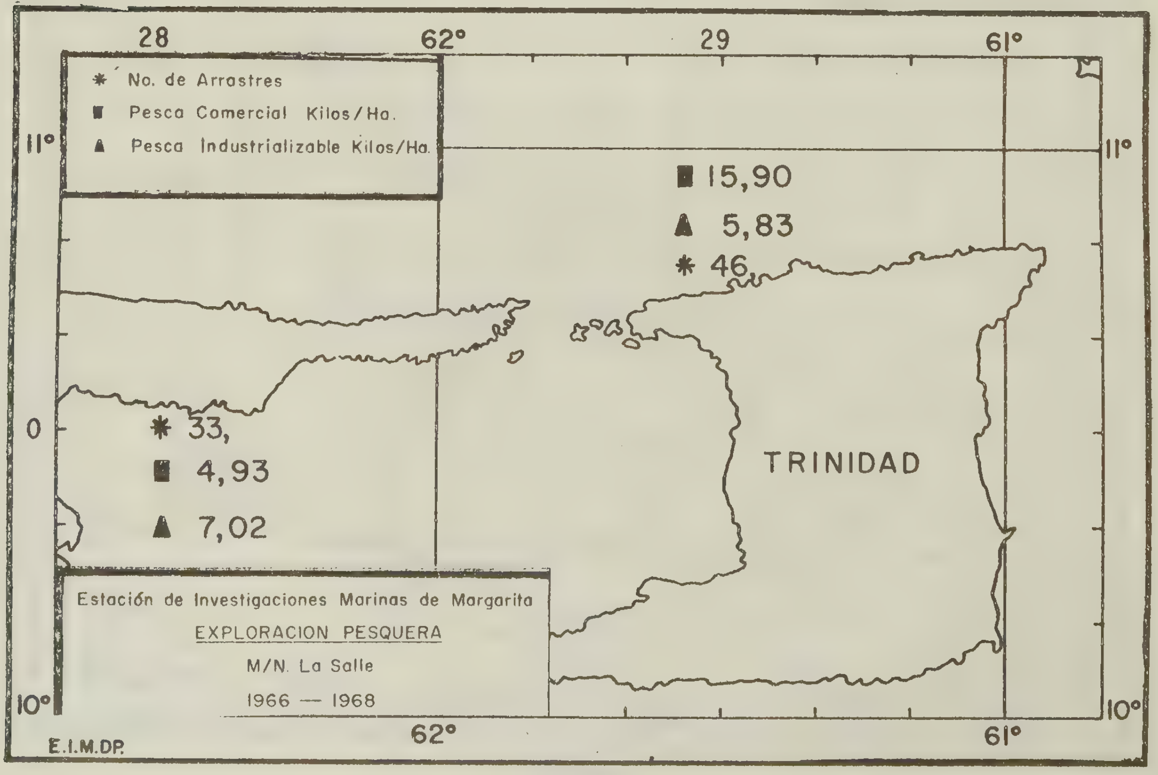

28
62°
29
61°
11°
11°
0
10°
10°
62°
61°
✱ No. de Arrastres
■ Pesca Comercial Kilos/Ha.
▲ Pesca Industrializable Kilos/Ha.
■ 15,90
▲ 5,83
✱ 46,
✱ 33,
■ 4,93
▲ 7,02
TRINIDAD
Estación de Investigaciones Marinas de Margarita
EXPLORACION PESQUERA
M/N. La Salle
1966 — 1968
E.I.M.DP.

Fig. 29

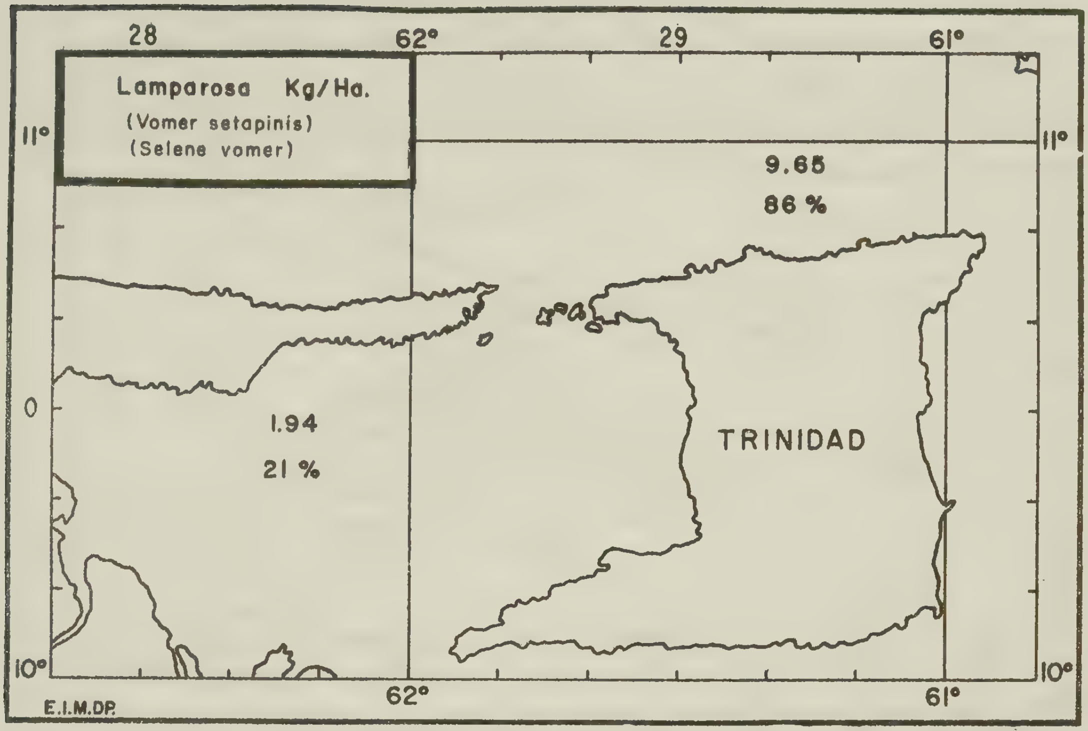

28
62°
29
61°
Lamparosa Kg/Ha.
(Vomer setapinis)
(Selene vomer)
11°
9.65
86 %
0
1.94
21 %
TRINIDAD
10°
E.I.M.DP.
62°
61°

Fig. 30

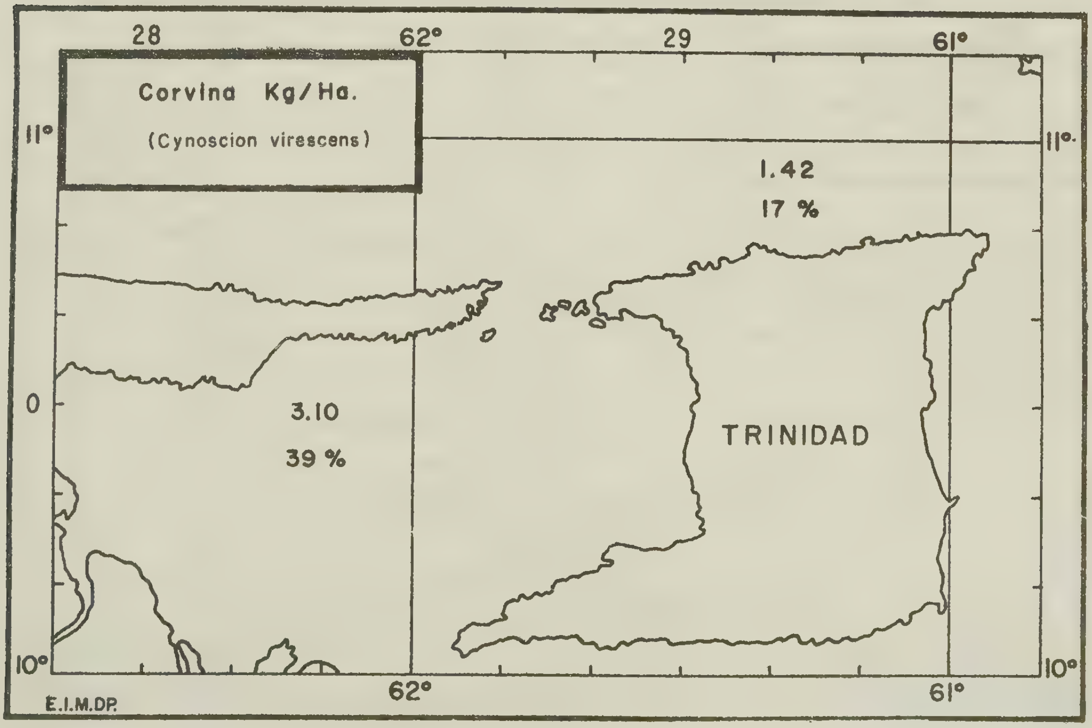

28
62°
29
61°
Corvina Kg/Ha.
(Cynoscion virescens)
11°
1.42
17 %
0
3.10
39 %
TRINIDAD
10°
E.I.M.DP.
62°
61°

Fig. 31

4.43

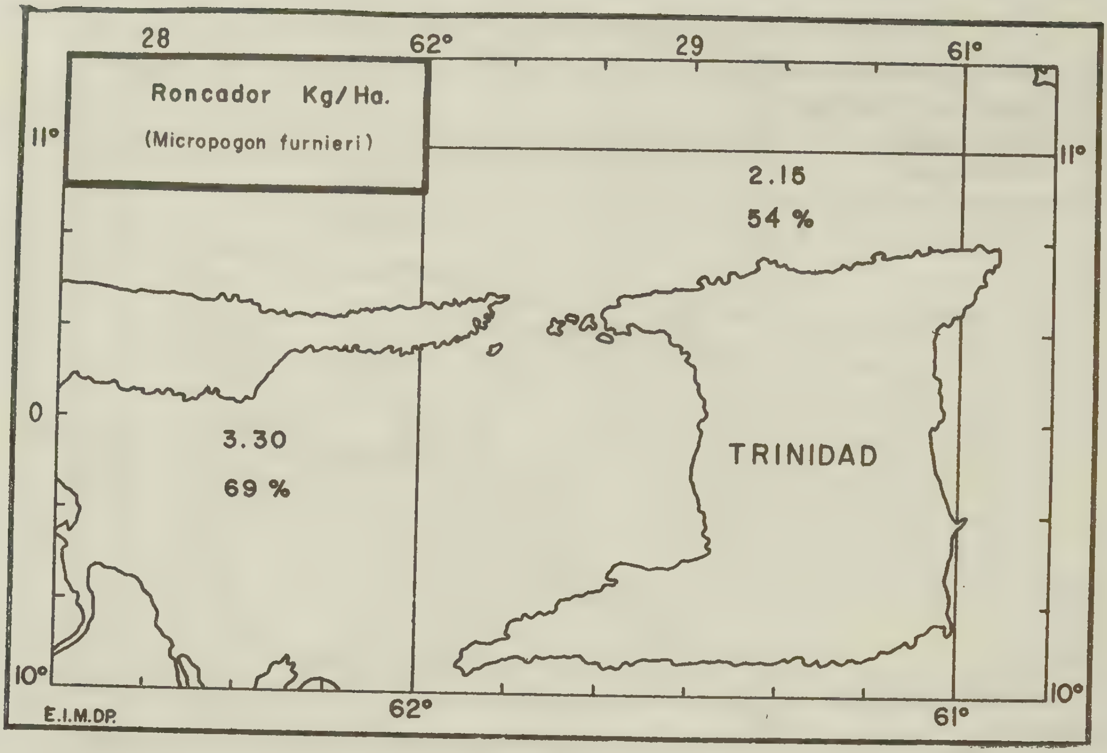

28
62°
29
61°
Roncador Kg/Ha.
(Micropogon furnieri)
11°
2.15
54 %
0
3.30
69 %
TRINIDAD
10°
E.I.M.DP.

Fig. 32

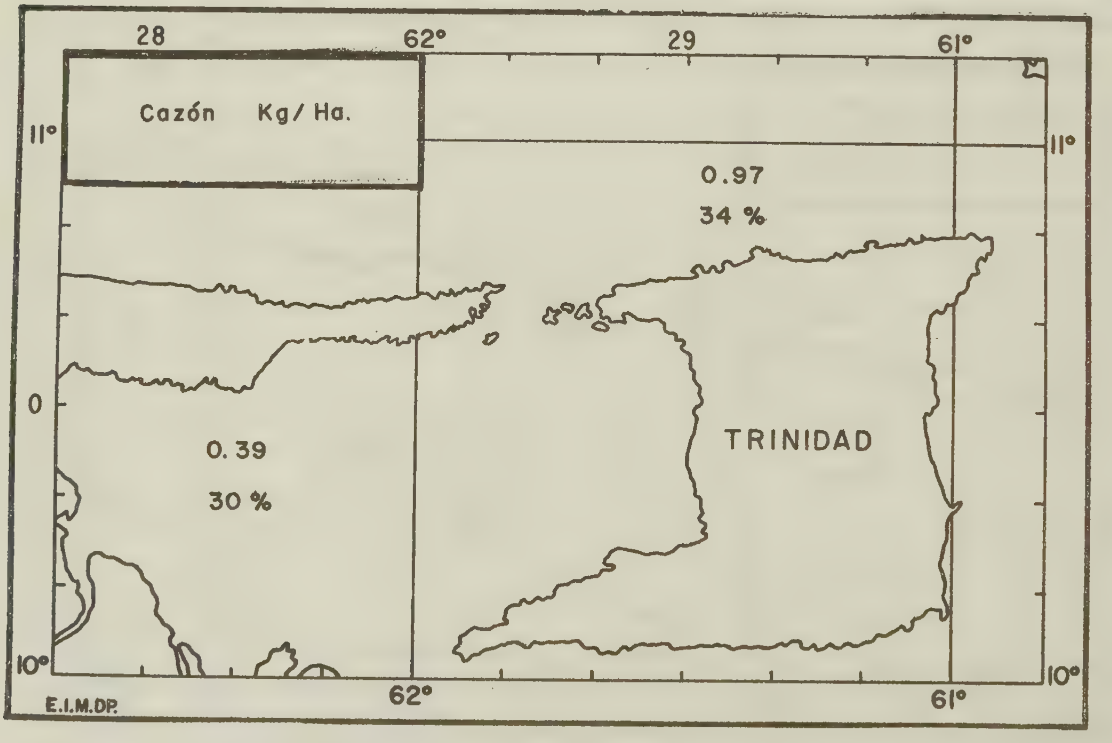

28
62°
29
61°
Cazón Kg/Ha.
11°
0.97
34 %
0
0.39
30 %
TRINIDAD
10°
E.I.M.DP.

Fig. 33

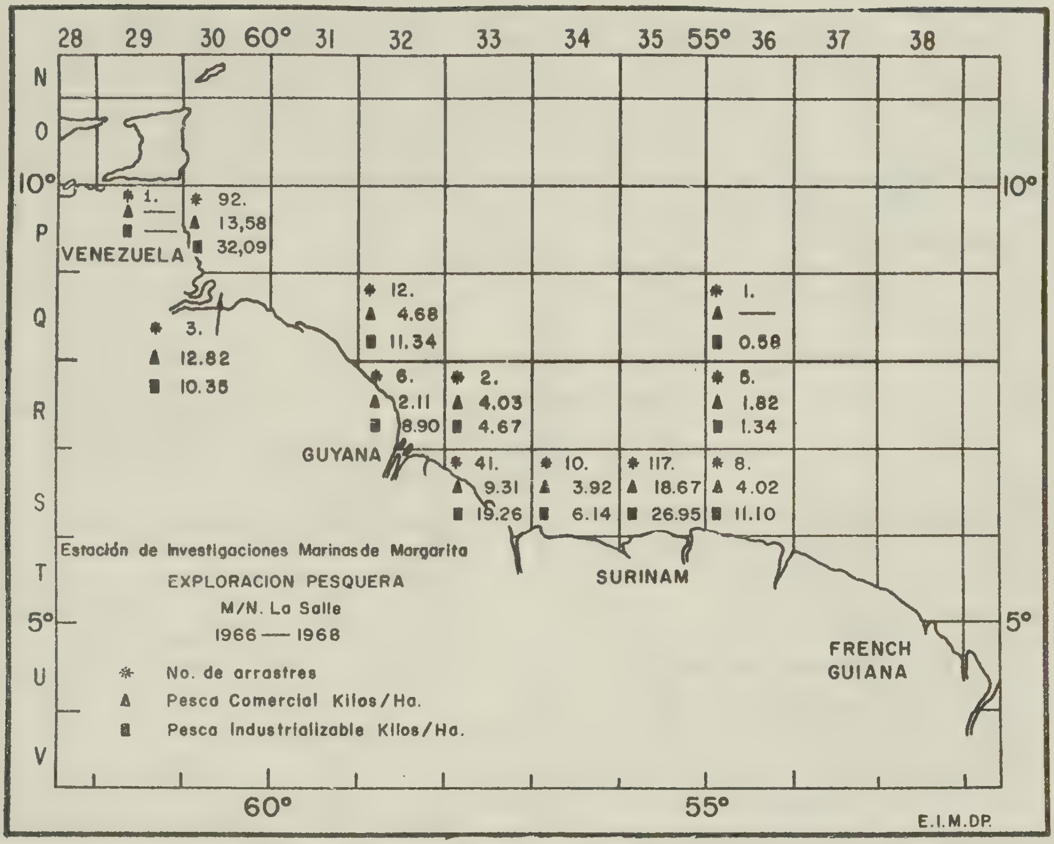

28 29 30 60° 31 32 33 34 35 55° 36 37 38
N
O
10°
P
Q
R
S
T
5°
U
V
10°
5°
VENEZUELA
GUYANA
SURINAM
FRENCH GUIANA
✻ 1.
▲ —
■ —
✻ 92.
▲ 13,58
■ 32,09
✻ 3.
▲ 12.82
■ 10.35
✻ 12.
▲ 4.68
■ 11.34
✻ 6.
▲ 2.11
■ 8.90
✻ 2.
▲ 4.03
■ 4.67
✻ 1.
▲ —
■ 0.58
✻ 5.
▲ 1.82
■ 1.34
✻ 41.
▲ 9.31
■ 19.26
✻ 10.
▲ 3.92
■ 6.14
✻ 117.
▲ 18.67
■ 26.95
✻ 8.
▲ 4.02
■ 11.10
Estación de Investigaciones Marinasde Margarita
EXPLORACION PESQUERA
M/N. La Salle
1966 —— 1968
✻ No. de arrastres
▲ Pesca Comercial Kilos/Ha.
■ Pesca Industrializable Kilos/Ha.
60°
55°
E.I.M.DP.

Fig. 34

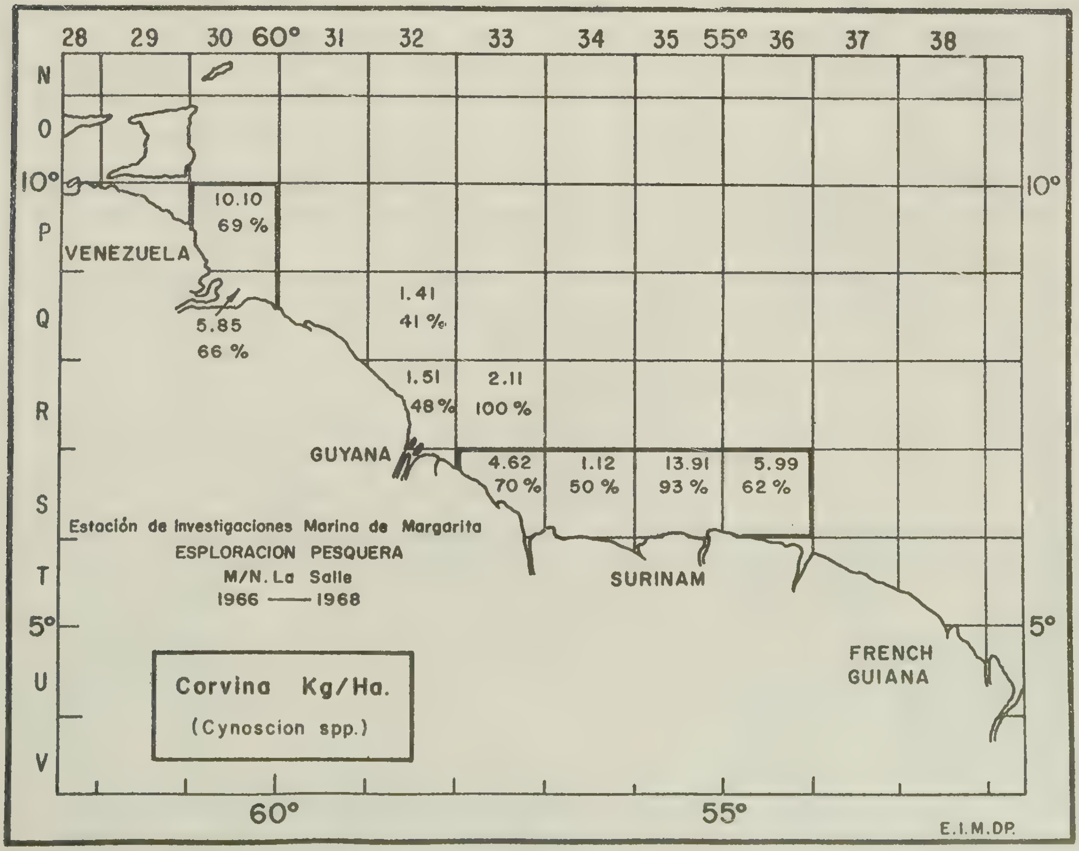

28 29 30 60° 31 32 33 34 35 55° 36 37 38
N
O
10°
P
Q
R
S
T
5°
U
V
10°
5°
VENEZUELA
GUYANA
SURINAM
FRENCH GUIANA
10.10
69 %
5.85
66 %
1.41
41 %
1.51
48 %
2.11
100 %
4.62
70 %
1.12
50 %
13.91
93 %
5.99
62 %
Estación de Investigaciones Marina de Margarita
ESPLORACION PESQUERA
M/N. La Salle
1966 —— 1968
Corvina Kg/Ha.
(Cynoscion spp.)
60°
55°
E.I.M.DP.

Fig. 35

4.43

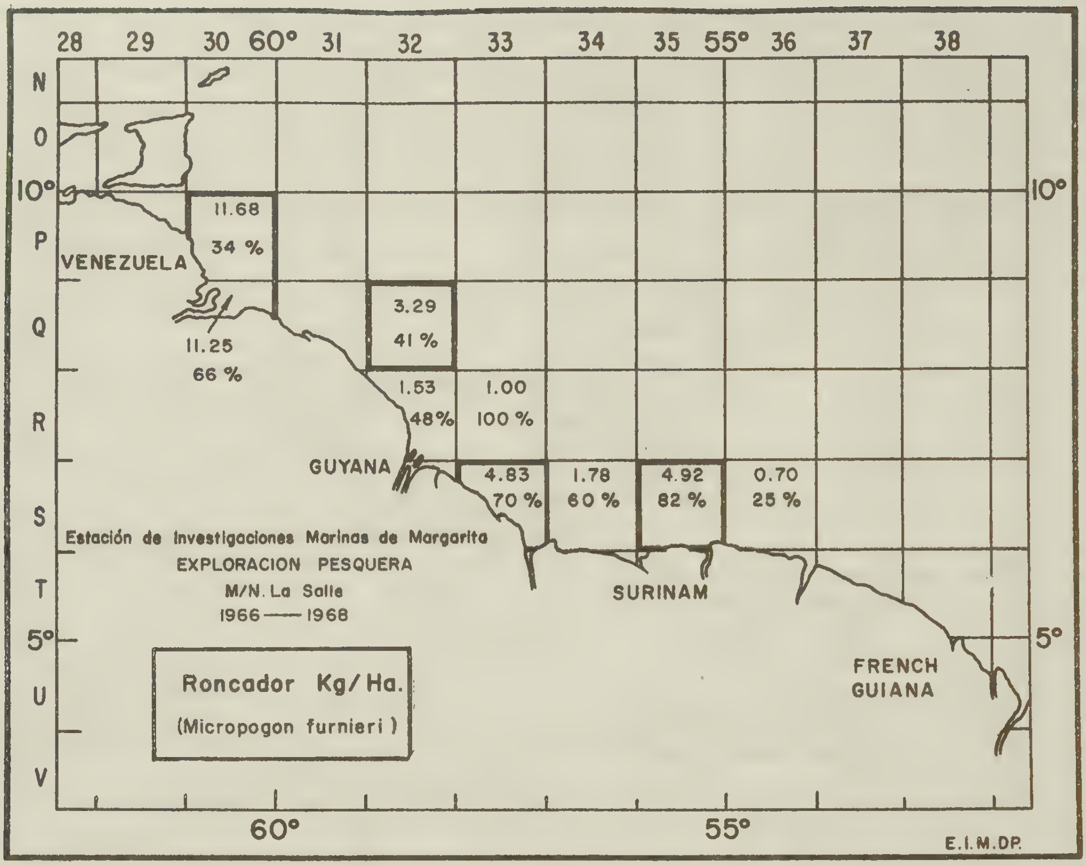

28
29
30
60°
31
32
33
34
35
55°
36
37
38
N
O
10°
P
Q
R
S
T
5°
U
V
10°
5°
VENEZUELA
GUYANA
SURINAM
FRENCH GUIANA
11.68
34 %
11.25
66 %
3.29
41 %
1.53
48%
1.00
100 %
4.83
70 %
1.78
60 %
4.92
82 %
0.70
25 %
Estación de Investigaciones Marinas de Margarita
EXPLORACION PESQUERA
M/N. La Salle
1966 —— 1968
Roncador Kg/Ha.
(Micropogon furnieri)
60°
55°
E.I.M.DP.

Fig. 36

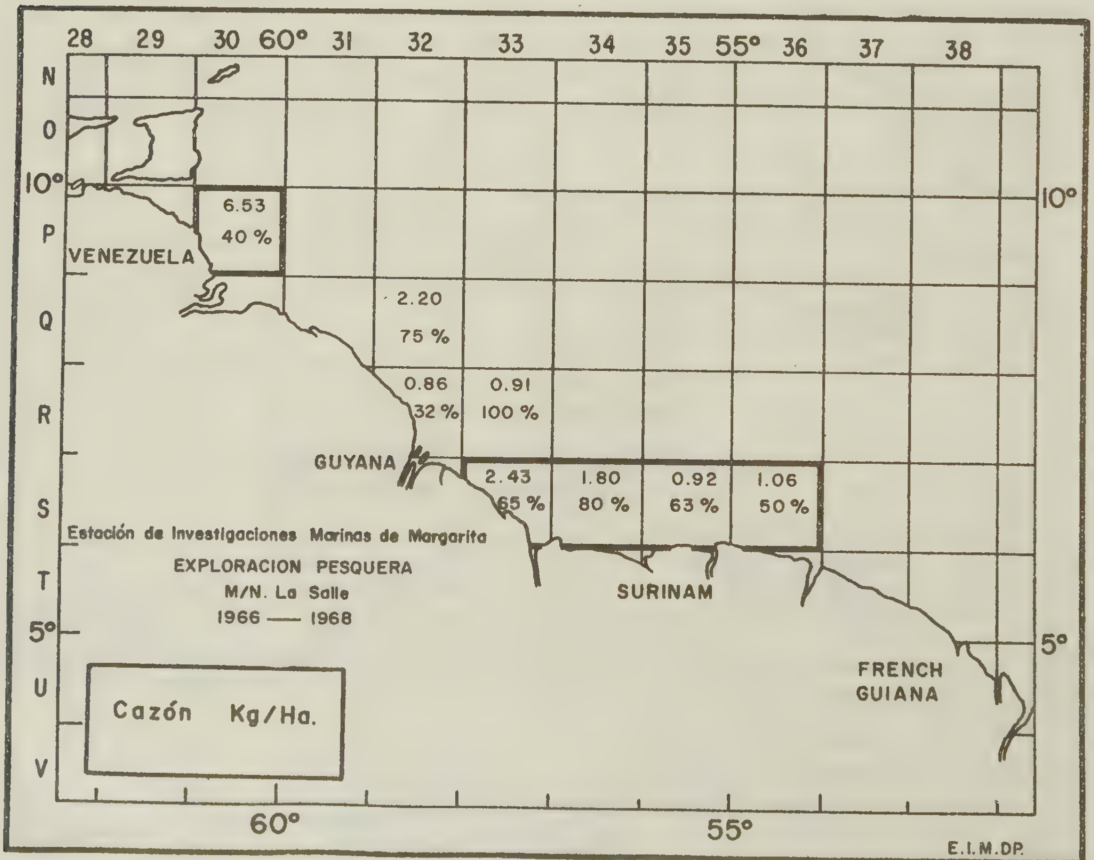
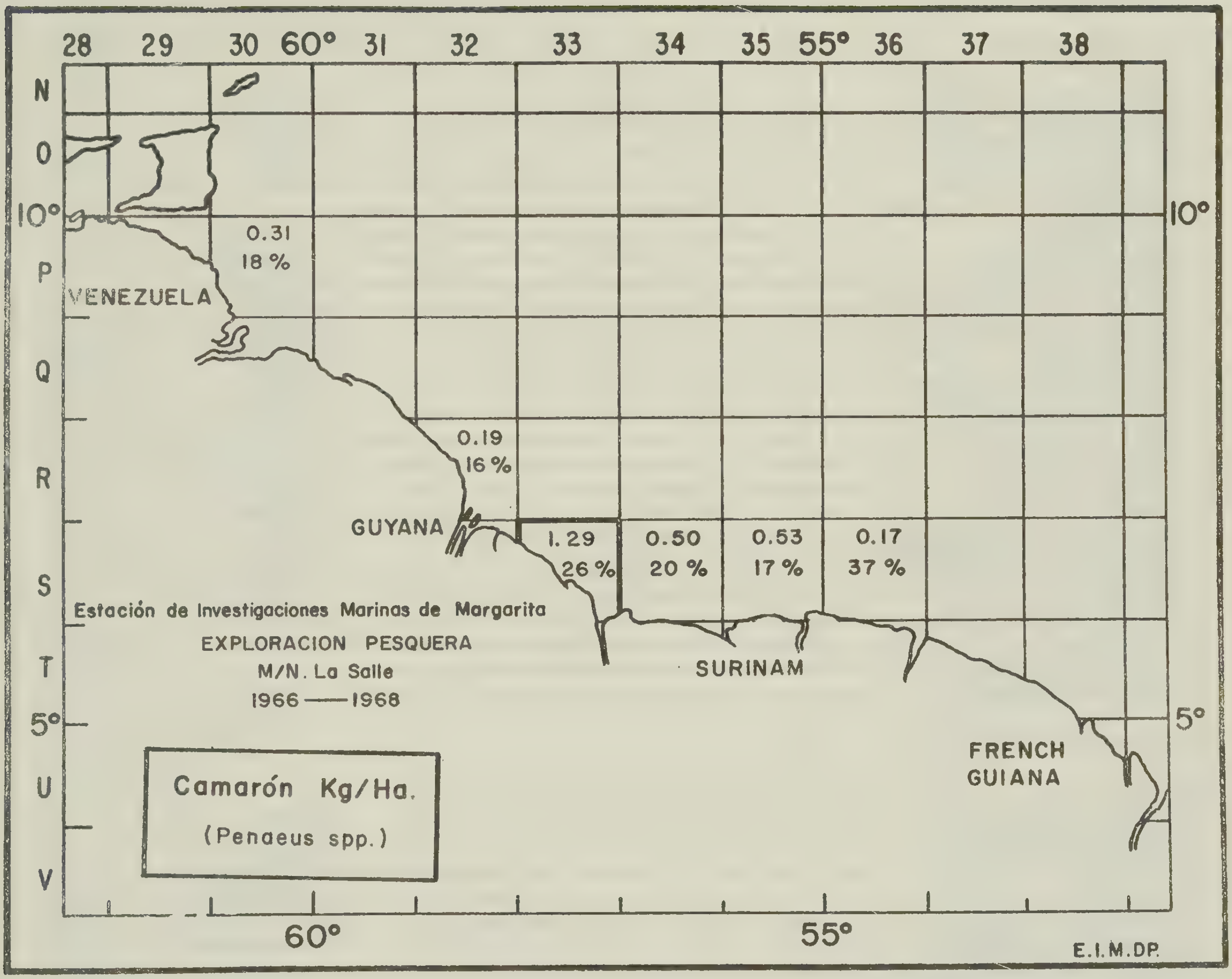

28
29
30
60°
31
32
33
34
35
55°
36
37
38
N
O
10°
P
Q
R
S
T
5°
U
V
10°
5°
VENEZUELA
GUYANA
SURINAM
FRENCH GUIANA
6.53
40 %
2.20
75 %
0.86
32 %
0.91
100 %
2.43
65 %
1.80
80 %
0.92
63 %
1.06
50 %
Estación de Investigaciones Marinas de Margarita
EXPLORACION PESQUERA
M/N. La Salle
1966 —— 1968
Cazón Kg/Ha.
60°
55°
E.I.M.DP.

Fig. 37


28
29
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60°
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32
33
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55°
36
37
38
N
O
10°
P
Q
R
S
T
5°
U
V
0.31
18 %
VENEZUELA
0.19
16 %
GUYANA
1. 29
26 %
0.50
20 %
0.53
17 %
0.17
37 %
Estación de Investigaciones Marinas de Margarita
EXPLORACION PESQUERA
M/N. La Salle
1966 —— 1968
SURINAM
FRENCH GUIANA
Camarón Kg/Ha.
(Penaeus spp.)
60°
55°
E.I.M.DP.

Fig. 38

4.43

APENDICE III

PECES CAPTURADOS EN LOS MARES DE GUAYANA POR LAS EXPEDICIONES DE LA M/N LA SALLE

Especies	Nombre común
Elasmobranquios	
Gyngymostoma cirratum	GATA
Rhizoprionodon lalandei	CAZON CHINO
Carcharhinus limbatus	MACUIRA
Carcharhinus porosus	CAZON
Carcharhinus oxirhinchus	
Carcharhinus sp.	
Mustelus higmani	VIUDA AMARILLA
Sphyrna lewini	CORNUA
Sphyrna tiburo	CORNUA
Sphyrna mokarran	CORNUA
Sphyrna tudes	CORNUA
Rhinobatos percellens	CHOLA
Pristis pectinatus	PEZ ESPADA
Dasyatis americana	RAYA
Dasyatis guttata	RAYA HOCICONA
Dasyatis geijskesi	RAYA
Gymnura micrura	GUAYANESA
Urotrygon microphthalmun	
Myliobatis freminvillei	CHUCHO
Aetobatus nari-nari	CHUCHO PINTADO
Narcine brasiliensis	TEMBLADOR
Diplobatis sp.	
Diplobatis pictus	
Rhinoptera bonasus	MANTA
Teleosteos	
Elope saurus	MALACHO
Albula nemoptera	RATON
Opisthonema oglinum	MACHUELO
Sardinella anchovia	SARDINA
Harengula sp.	CARAPACHONA
Harengula clupeola	CARAPACHONA
Harengula pensacolae	CARAPACHONA
Chirocentrodon bleekerianus	
Pellona harroweri	SARDINA
Odontognathus mucronatus	
Anchoa spinifer	
Anchoa cubana	CAMIGUANA
Anchoa howelli	CAMIGUANA
Anchoviella estanquae	CAMIGUANA
Anchoviella sp.	CAMIGUANA
Anchoviella hubbsi	CAMIGUANA
Licengraulis sp.	
Licengraulis batesii	
Cetengraulis edentulus	RABO AMARILLO
Synodus sp.	GUARIPETE
Synodus poeyi	GUARIPETE
Synodus foetens	GUARIPETE
Saurida caribbaea	GUARIPETE
Saurida sp.	GUARIPETE
Parasudis truculentus	
Bagre bagre	BAGRE CACUMO

Especies	Nombre común
Bagre marinus	BAGRE CACUMO
Arius spixii	BAGRE CUINCHE
Arius spp. (grandicassis + stritticassis)	BAGRE
Congrina spp.	
Muraenesox savanna	TIESO
Ophichthus parilis	TIESO
Hoplunnis diomedianus	
Macrurus sp.	
Coelorhynchus carminatus	
Polimixia lowei	
Antigonia capros	
Antigonia combatia	
Sphyraena guachancho	PICUA LISTA AMARILLA
Sphyraena picudilla	PICUA CHINA
Polydactilus virginicus	BARBUDO
Centropomus undecimalis	ROBALO
Centropomus ensiferus	ROBALO MAQUEQUE
Epinephelus itajara	GUASA
Epinephelus niveatus	CHERNA
Diplectrum radiale	BOLO
Serranus atrobranchus	
Pronotogrammus aureorubens	
Epigonus of. pandionis	
Priacanthus arenatus	CATALUCIA
Pomatomus saltatrix	ANCHOA
Parascombrops sp.	
Rachycentron canadus	BACALLAO
Trachinotus cayenensis	PAMPANO ZAPATERO
Trachinotus carolinus	PAMPANO AMARILLO
Selar crumenophthalmus	CATACO OJON
Trachurus lathami	CATACO GARRETON
Caranx latus	OJO GORDO
Caranx hippos	JUREL
Caranx crysos	"ATUN"
Hemicaranx amblyrhynchus	VUELA CHICHARRA
Chloroscombrus chrysurus	CHICHARRA
Vomer setapinnis	LAMPAROSA
Selene vomer	CARA CABALLO
Oligoplites spp.	ZAPATERO
Oligoplites saliens	ZAPATERO
Oligoplites palometa	ZAPATERO
Lutjanus purpureus	PARGO COLORADO
Lutjanus synagris	PARGO GUANAPO
Pristipomoides aquilonaris	PANCHITO
Eucinostomus sp.	ESPAÑOLA
Diapterus sp.	CAITIPA
Genyatremus luteus	TORROTO
Pomadasys corvinaeformis	
Orthopristis ruber	COROCORO
Conodon nobilis	CANARIO
Haemulon aurolineatum	CUJI
Haemulon boschmae	RUYI-RUYI
Haemulon steindachneri	CHERECHERE
Ctenosciaena gracilicirrhus	MAROTA
Micropogon furnieri	RONCADOR
Stellifer rastrifer	
Stellifer sp.	

4.43

Especies	Nombre común
Stellifer stellifer	
Stellifer brasiliensis	
Stellifer microps	
Ophioscion sp.	
Ophioscion costaricensis	
Bairdiella sanctae-luciae	CARA-CARE
Macrodon ancylodon	TONQUICHA
Cynoscion jamaicensis	TONQUICHA
Cynoscion bairdi	CURVINATA
Cynoscion leiarchus	CURVINATA
Cynoscion virescens	CURVINA
Cynoscion acoupa	CURVINA
Cynoscion similis	TONQUICHA
Menticirrhus martinicensis	LAMBE
Isopisthus parvipinnis	
Polyclemus brasiliensis	MAMO
Nebris microps	RONCO
Larimus breviceps	BOMBACHE
Paralonchurus elegans	LAMBE
Lonciurus lanceolatus	
Upeneus parvus	SALMONETE DE CHARCO
Chaetodipterus faber	PAGUARA
Halichoeres caudalis	LORO
Opisthognathus macrognatus	TRAGANAVI
Bembrops anatirostis	
Brotula barbata	
Neobythies gilli	
Lepophidium profundorum	
Merluccius sp.	
Lepophidium sp.	
Callyonimus agassizi	
Bollmannia sp.	
Trichiurus lepturus	TAJALI
Scomberomorus maculatus	CARITE PINTADO
Scomberomorus cavalla	CARITE LUCIO
Peprilus paru	PAMPANO MONO
Cubiceps nigriargenteus	
Scorpaena plumieri	
Scorpaena brasiliensis	SAPO CHAZNETE
Scorpaena melasma	
Pontinus longispinis	
Prinotus stearnsi	GALLINA
Prinotus punctatus	GALLINA
Prinotus sp.	
Bellator ribeiroi	
Peristedion imberbe	
Dactylopterus volitans	VOLADOR
Paralichthys tropicus	ABREVES
Engyophrys sentus	ABREVES
Syacium gunteri	ABREVES
Citharichthys spilopterus	ABREVES
Citharichthys crossotus	ABREVES
Citharichthys sp.	ABREVES
Cyclopsetta chittendeni	ABREVES
Monolene sp.	ABREVES
Poecilopsetta albomarginata	ABREVES
Achirus sp.	

Especies	Nombre común
Gymnachirus nudus	
Symphurus plagusia tessellata	
Symphurus sp.	
Echeneis naucrates	PEGA
Balistes vetula	CACHUA
Alutera sp.	CACHUA PERRA
Monocanthus sp.	CACHUA PERRA
Stephanolepis bispidus	
Colomesus psittacus	CORROTUCHO
Lagocephalus laevigatus	MONDEQUE
Sphoeroides sp.	CORROTUCHO
Sphoeroides testudineus	CORROTUCHO
Chylomycterus antillarum	TAMBORIL
Lactophrys tricornis	TORITO
Batrachoides surinamensis	SAPO
Porichthys porosissimun	SAPO CADENA
Ogcocephalus spp.	MURCIELAGO
Halieutichthys sp.	
Antennarious scaber	MURCIELAGO

THE TUNA FISHERY OF VENEZUELA WITH NOTES ON OTHER SCOMBROIDS OF POTENTIAL COMMERCIAL VALUE

by

RAYMOND C. GRIFFITHS
UNDP/SF/FAO Fisheries Research and Development
Project, Caracas, Venezuela

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3	DISTRIBUTION OF THE FISHING EFFORT	96
4	DISTRIBUTION OF THE CATCH	96
5	CATCH PER UNIT EFFORT	96
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1 INTRODUCTION

The tuna fishery of Venezuela is a little more than a decade old and coincides with the rise of the international tuna longline fishery in the Atlantic Ocean. In a way not always clearly appreciated in Venezuela the fortunes of the Venezuelan fishery are related to those of the international fishery. Although the connexion between Eastern and Western Atlantic stocks has been neither proved nor disproved, it is generally accepted, at least provisionally, that one exists between Western Atlantic and Caribbean stocks so that the Venezuelan fishery exploits a stock already under considerable pressure.

The purpose of this paper is to give the main information about the Venezuelan tuna fishery as far as is possible from the still inadequate statistics, relating it to the international fishery for tuna. Some of the most obvious questions about the factors affecting this fishery are raised as a basis for the further work needed to understand and regulate the stocks. In keeping with the theme of the Conference, some of the questions raised concern possible oceanographic influences.

The previous work on which the author has largely depended, apart from his own limited studies, has been done by Rodrigues Lima and Wise (1962) on the Brazilian tuna fisheries, Wise (1968) and Wise and Le Guen (MS) on the Japanese Atlantic longline tuna fishery, Griffiths and Nemoto (1967) and Griffiths and Simpson (1968) on the Venezuelan tuna fishery. This list is partial but gives an acceptably wide coverage.

2 SPECIES

The chief species of tuna caught by Venezuelan longliners is the yellowfin, Thunnus albacares, which usually makes up about 70% of the total catch. The second species, making up about 20% of the catch, is the albacore, T. alalunga. Small and variable amounts of bigeye, T. obesus, and blackfin, T. atlanticus, are taken. From time to time a bluefin, T. thynnus, is caught. The longliners catch incidentally small quantities of sharks, marlins, swordfish, and other species. In short, a typical spectrum of Atlantic longline catches.

4.5

3 DISTRIBUTION OF THE FISHING EFFORT

The distribution of the fishing effort of Venezuelan longliners is not completely known. Some useful indications were given by Griffiths and Nemoto (1967) based on the Venezuelan-Japanese longliners, but they omitted the information from an important part of the fleet: the Venezuelan longliners, of which there are about forty and most of which have been converted from coastal bottom longliners for snappers and groupers. These vessels are much smaller than the half dozen vessels brought in from Japan and have, therefore, a much smaller radius of action, which in turn affects the distribution of their effort and catch. We have available fishing records of varying quality from about 60% of the tuna fishing fleet 40-50% of the time.

The distribution of effort of the farther-ranging Venezuelan-Japanese vessels between 1960 and 1963 given by Griffiths and Nemoto can be compared with that of the fleet as a whole during 1964 and 1965 (Figures 1 and 2). Although somewhat more restricted the preferred fishing areas are still a hundred miles or more offshore from the central and eastern Venezuelan coasts, in the Caribbean Sea, and to the east and southeast of Trinidad, in the Atlantic Ocean. There are seasonal shifts of the effort between these two areas and perhaps even within each, but these are not clear and for most purposes can be disregarded.

4 DISTRIBTUION OF THE CATCH

As with fishing effort the distribution of the catches made by the Venezuelan-Japanese longliners between 1960 and 1963 were given by Griffiths and Nemoto (1967). More information from a sample of the whole fleet is available for 1964 and 1965. But, whereas the data from the "Japanese" vessels were in terms of numbers of specimens, the data from the larger, local element of the fleet are in terms of weight in kilograms. This makes it difficult to display the data continuously between 1960 and 1965. Therefore, in Figures 3 and 4, only the distribution of catches of tunas for 1964 and 1965 are given.

The total annual landings of tuna in thousands of metric tons by Venezuelan vessels since 1960 were as follows:

Year	1960	1961	1962	1963	1964	1965	1966
Catch	2.06	2.01	3.54	3.09	1.94	1.83	2.14

About 65% of the catch is landed in eastern Venezuelan ports, the balance in La Guaira, central Venezuela. Most of the catch landed at the eastern ports (Cumaná; Mariguitar) is canned, the offal being converted to meal, whereas that landed at La Guaira is mostly sold as fresh fish in the metropolitan area. The price for gutted fish on the dock ex-vessel is now about US$470/metric ton.

5 CATCH PER UNIT OF EFFORT

The unit of effort for this fishery is 100 hooks. Since the longline is, as a rule, set at dawn and brought in at sunset the unit of effort is practically equivalent to 100 hooks-days and the worst dangers in not standardizing the vessels (by power or size, for instance) are minimized.

The catch per unit of effort may be taken as an index of apparent abundance, and for this fishery Griffiths and Nemoto have established that the extreme values (of catch per day) often found in the eastern Pacific baitboat (Griffiths, 1960) in 1° rectangles lightly fished do not arise nearly so often in this fishery. Whereas in the Pacific fishery the elimination of 1° rectangles fished less than, say, five or ten days in a quarter produced appreciable changes in the overall average catch per unit of effort, in this fishery no such changes occurred. This means that a low level of effort provides more or less as good an index of apparent abundance as a high level.

The catch per unit of effort has declined steadily since 1960 (Figure 5) in a way similar to that for the yellowfin taken by the Japanese Atlantic longline fishery (Wise and Le Guen, MS; Wise, 1968). Since yellowfin dominate Venezuelan catches this comparison is reasonable.

During this decline, however, a certain periodicity appears to have existed. Griffiths and Nemoto indicated that the yellowfin in the Caribbean area had a two-year cycle of abundance and Wise and Le Guen's (MS) data for this area agree fairly well.

Their data also support rather strongly a similar suggestion by Griffiths and Nemoto that albacore in the Caribbean, as well as in the Guiana region, showed an annual cycle of abundance. Wise and Le Guen's data from the Guianas area suggest an annual cycle for yellowfin and Griffiths and Nemoto's data

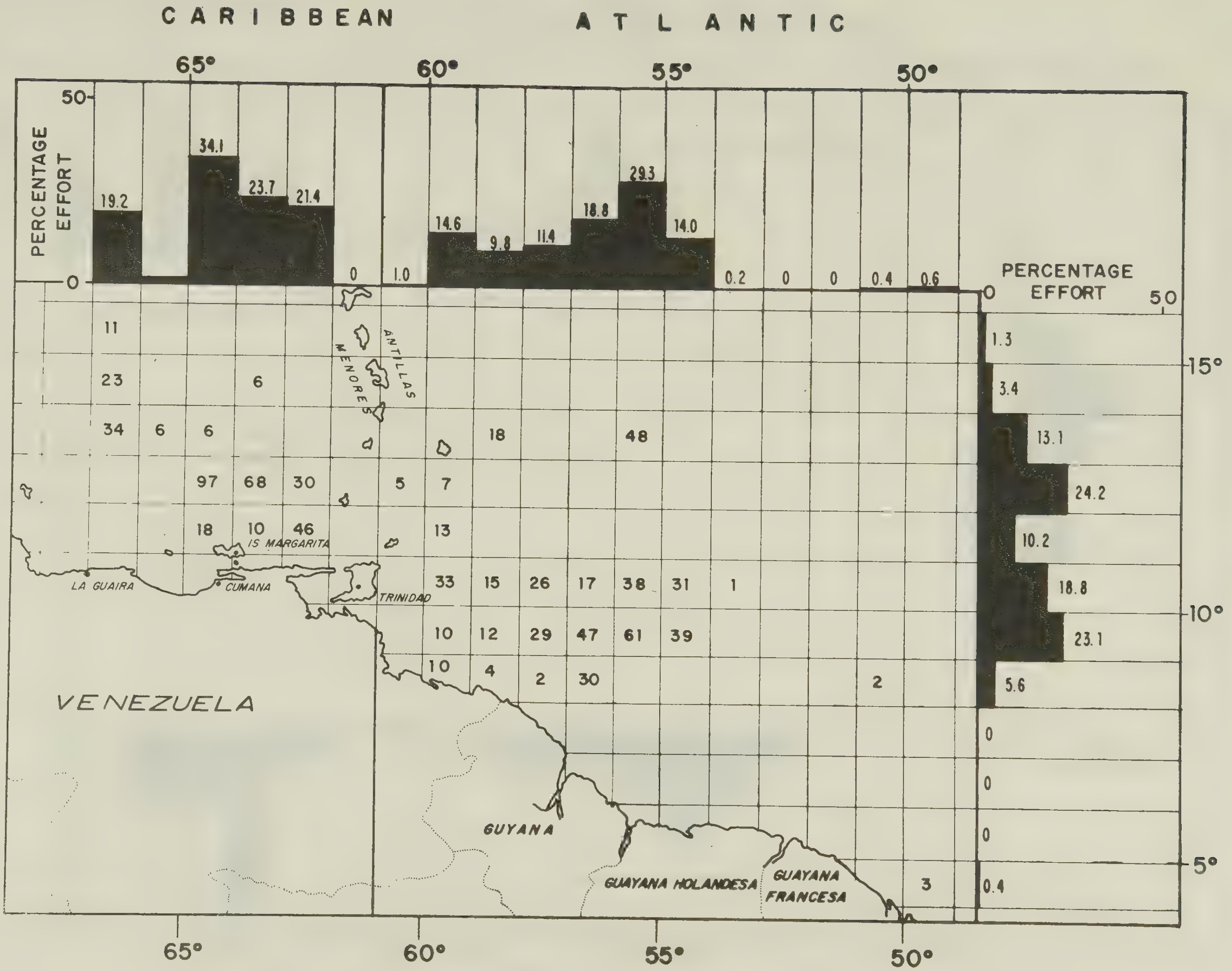
CARIBBEAN
ATLANTIC
65°
60°
55°
50°
15°
10°
5°
PERCENTAGE EFFORT
0
50
19.2
34.1
23.7
21.4
0
1.0
14.6
9.8
11.4
18.8
29.3
14.0
0.2
0
0
0.4
0.6
1.3
3.4
13.1
24.2
10.2
18.8
23.1
5.6
0
0
0
0.4
11
23
6
34
6
6
18
48
97
68
30
5
7
18
10
46
13
33
15
26
17
38
31
1
10
12
29
47
61
39
10
4
2
30
2
3
ANTILLAS MENORES
IS MARGARITA
LA GUAIRA
CUMANA
TRINIDAD
VENEZUELA
GUYANA
GUAYANA HOLANDESA
GUAYANA FRANCESA

Fig. 1 The distribution of fishing effort in thousands of hooks and the percentage effort by degrees of latitude and longitude (by region) for the Venezuelan tuna fishery in 1964

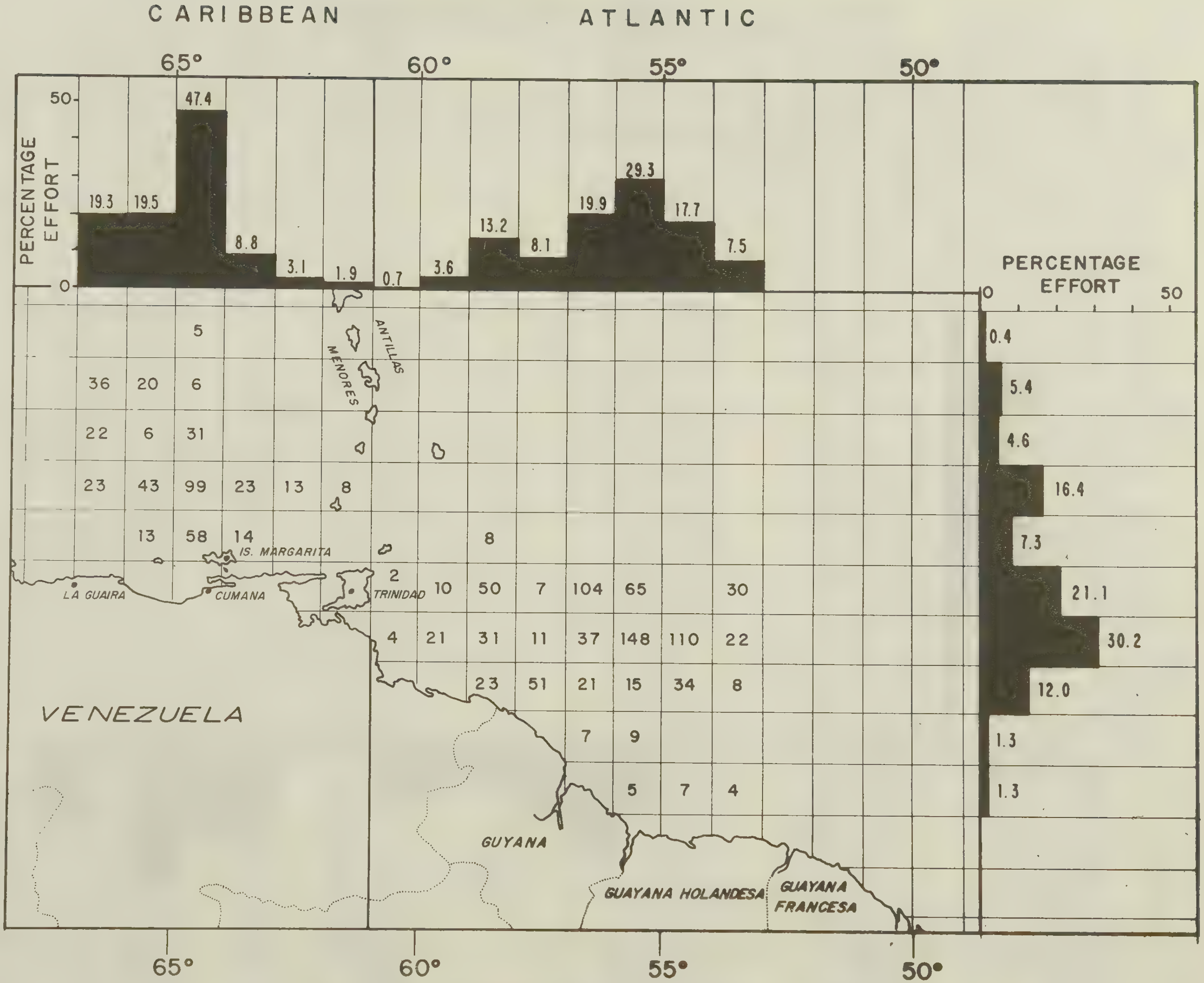
CARIBBEAN
ATLANTIC
65°
60°
55°
50°
PERCENTAGE EFFORT
50
0
19.3
19.5
47.4
8.8
3.1
1.9
0.7
3.6
13.2
8.1
19.9
29.3
17.7
7.5
PERCENTAGE EFFORT
0
50
0.4
5.4
4.6
16.4
7.3
21.1
30.2
12.0
1.3
1.3
5
36
20
6
22
6
31
23
43
99
23
13
8
13
58
14
8
2
10
50
7
104
65
30
4
21
31
11
37
148
110
22
23
51
21
15
34
8
7
9
5
7
4
ANTILLAS MENORES
IS. MARGARITA
LA GUAIRA
CUMANA
TRINIDAD
VENEZUELA
GUYANA
GUAYANA HOLANDESA
GUAYANA FRANCESA

Fig. 2 The distribution of fishing effort in thousands of hooks and the percentage effort by degrees of latitude and longitude (by region) for the Venezuelan tuna fishery in 1965

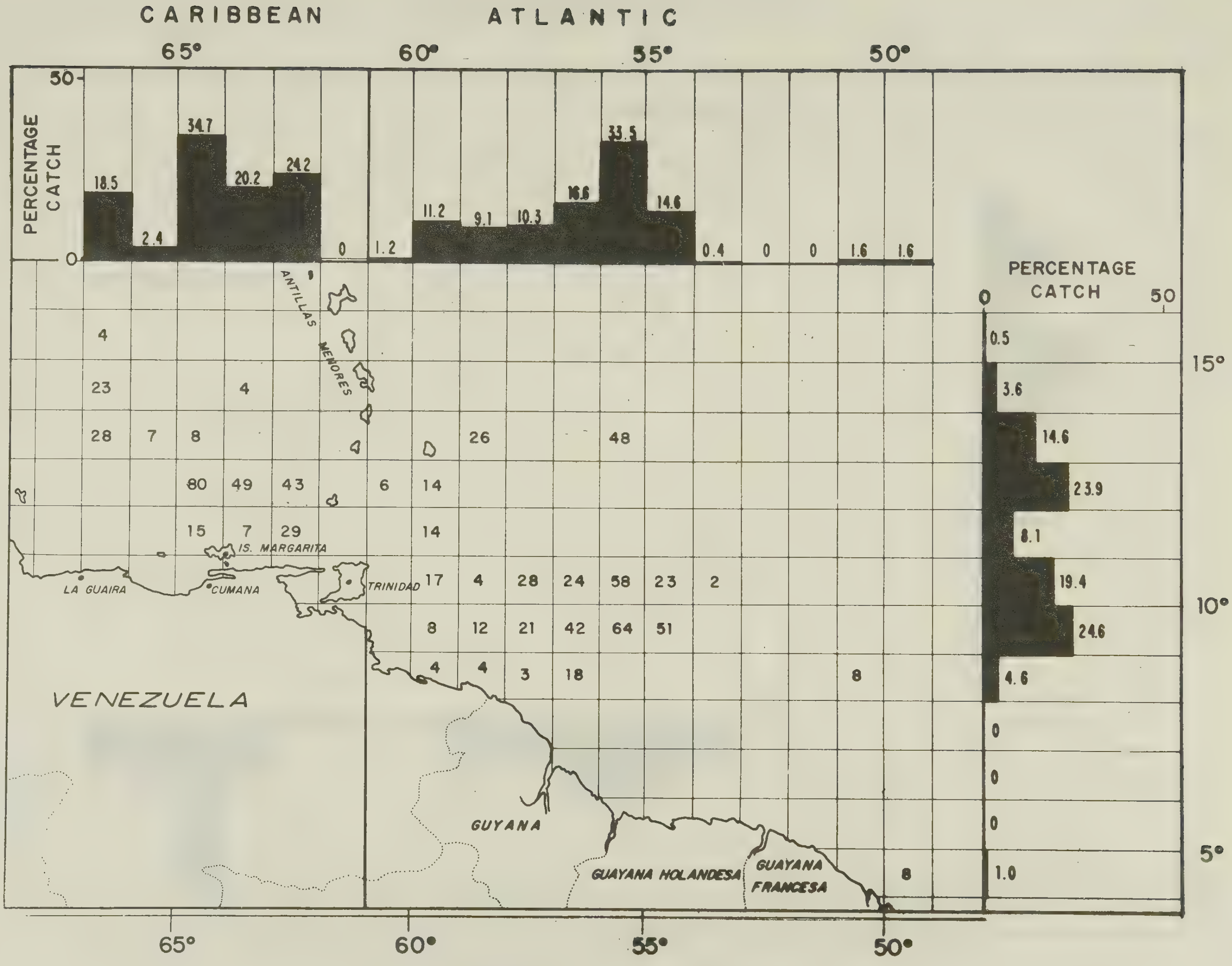
CARIBBEAN
ATLANTIC
65°
60°
55°
50°
PERCENTAGE CATCH
50
0
18.5
2.4
34.7
20.2
24.2
0
1.2
11.2
9.1
10.3
16.6
33.5
14.6
0.4
0
0
1.6
1.6
PERCENTAGE CATCH
0
50
0.5
3.6
14.6
23.9
8.1
19.4
24.6
4.6
0
0
0
1.0
15°
10°
5°
4
23
4
28
7
8
26
48
80
49
43
6
14
15
7
29
14
17
4
28
24
58
23
2
8
12
21
42
64
51
4
4
3
18
8
8
ANTILLAS MENORES
IS. MARGARITA
TRINIDAD
LA GUAIRA
CUMANA
VENEZUELA
GUYANA
GUAYANA HOLANDESA
GUAYANA FRANCESA

Fig. 3 The distribution of catch in metric tons and the percentage catch by degrees of latitude and longitude (by region) for the Venezuelan tuna fishery in 1964

4.5

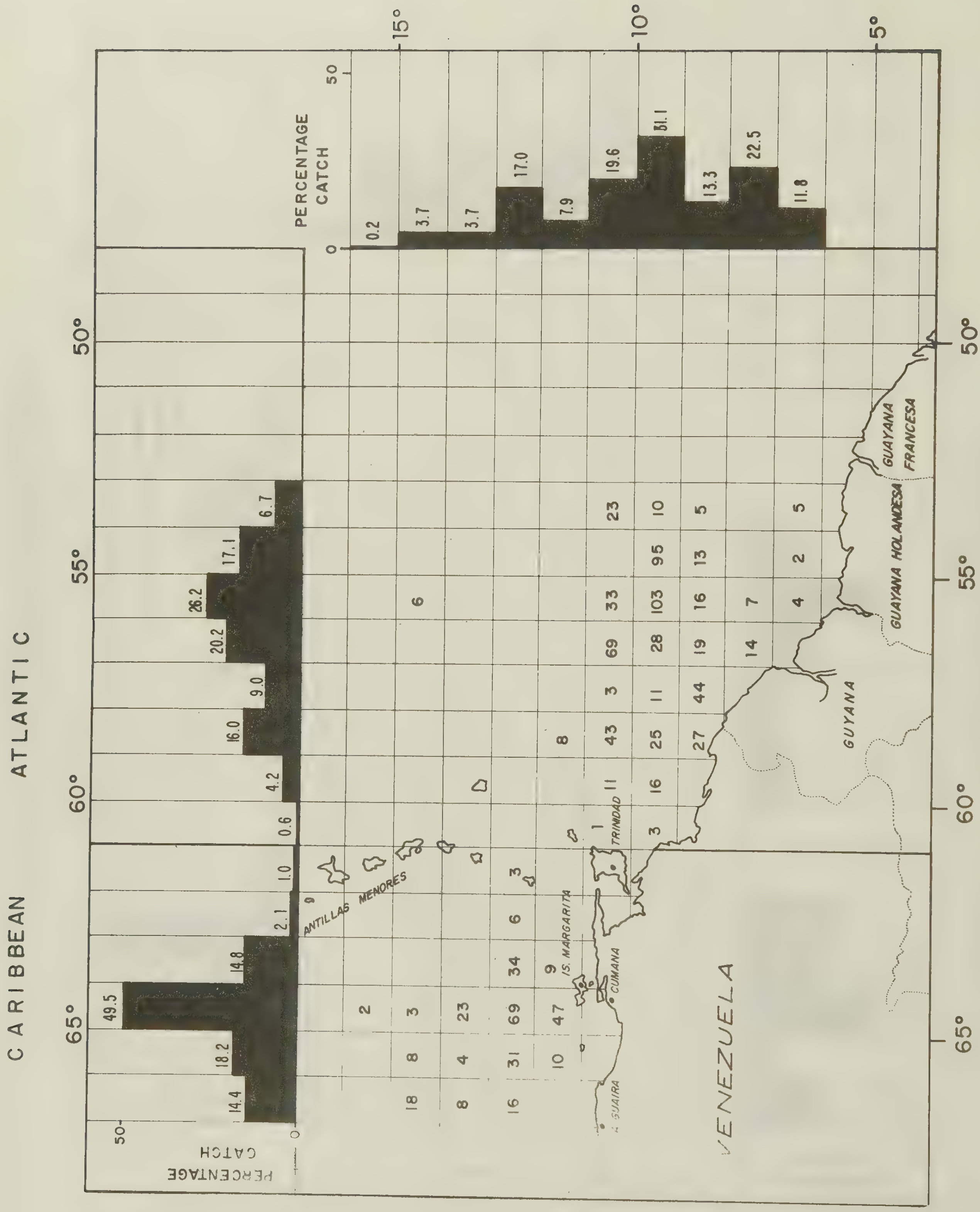
CARIBBEAN
ATLANTIC
65°
60°
55°
50°
15°
10°
5°
PERCENTAGE CATCH
0
50
14.4
18.2
49.5
14.8
2.1
1.0
0.6
4.2
16.0
9.0
20.2
26.2
17.1
6.7
0.2
3.7
3.7
17.0
7.9
19.6
31.1
13.3
22.5
11.8
18
8
16
8
4
31
10
2
3
23
69
47
34
6
9
3
1
11
3
16
43
25
27
8
3
11
44
69
28
19
14
6
33
103
16
7
4
95
13
2
23
10
5
5
ANTILLAS MENORES
IS. MARGARITA
TRINIDAD
CUMANA
LA GUAIRA
VENEZUELA
GUYANA
GUAYANA HOLANDESA
GUAYANA FRANCESA

Fig. 4 The distribution of catch in metric tons and the percentage catch by degrees of latitude and longitude (by region) for the Venezuelan tuna fishery in 1965

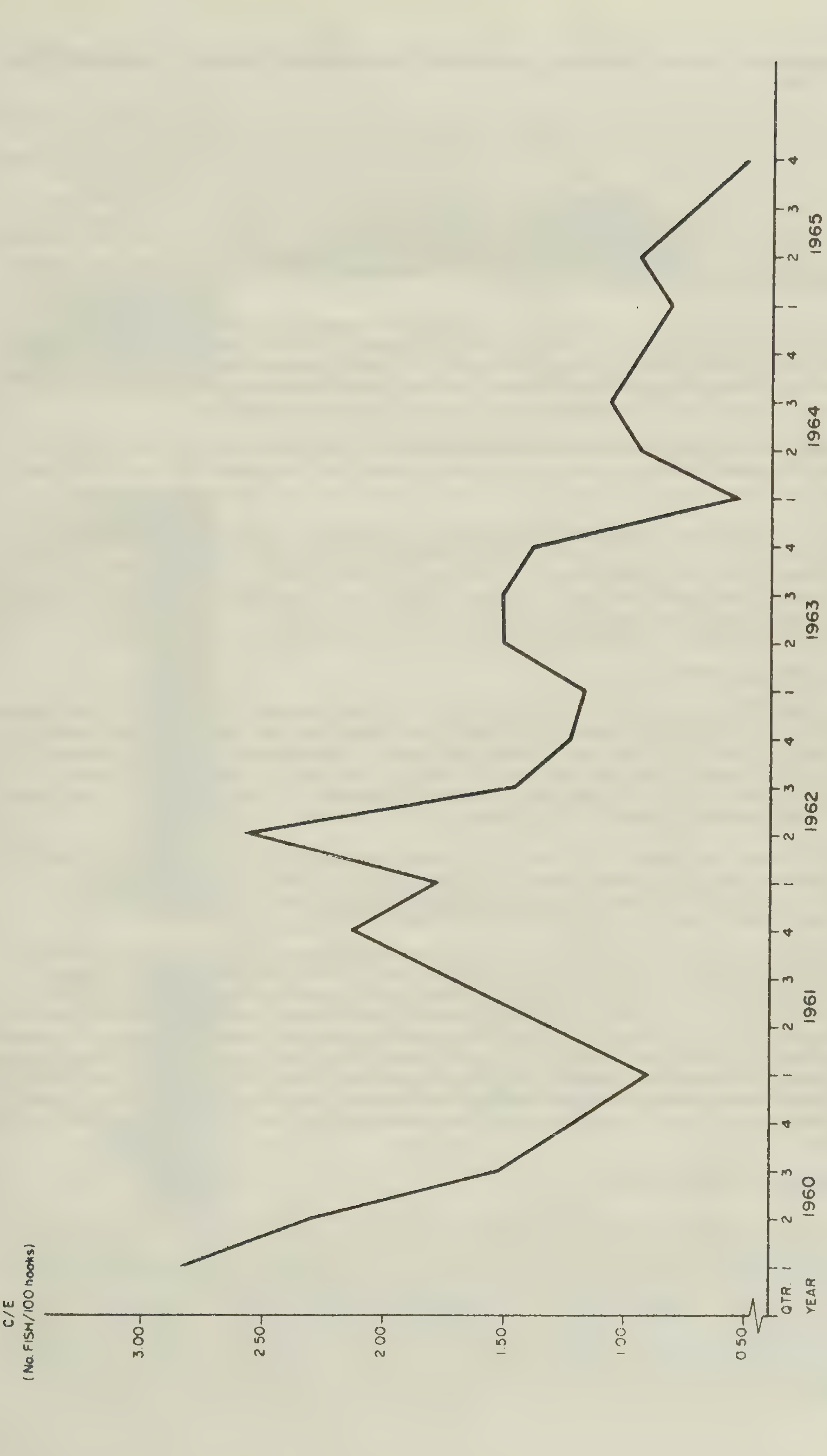

Fig. 5 The mean catch (No. of fish) per unit of effort (100 hooks) by quarters for the years 1960 to 1965 for the Venezuelan tuna fishery. The unweighted index of apparent abundance has been used and numbers of fish for the 1964 and 1965 values have been estimated from the corresponding weights and from numbers/100 hooks taken by the Venezuelan-Japanese vessels only

roughly agree. The agreement, however imperfect, is certainly encouraging, in view of the scanty data from the Venezuelan fishery.

By the somewhat rough and ready device of grouping quarterly average catch rates according to their ranks within each year, Griffiths and Simpson (1968) showed that yellowfin in the Caribbean had no marked seasonal abundance (no modulation of the two-year wavelength, so to speak) whereas in the Atlantic (meaning in effect the northwestern part of Wise and Le Guen's Guianas area) the second and third quarters were a period of seasonally high abundance. The far fewer data of the Venezuelan fishery do not therefore substantiate Wise and Le Guen's result that the Caribbean catch rate for yellowfin is similar to that of the Guianas area three months later. Nevertheless the reduced abundance of yellowfin in the Guianas in the first and last quarters raises a question of where the yellowfin may have migrated to cause the comparatively rapid seasonal changes.

Griffiths and Simpson also differ from Wise and Le Guen with respect to albacore, the former suggesting high seasonal abundance in the third and fourth quarters in the Guianas area and in the fourth and first quarters in the Caribbean, whereas Wise and Le Guen indicate that the two areas are similar. Nevertheless they found highest catch rates in both areas generally at the beginning of the year and the Venezuelan data do not contradict this fact in any significant way.

Taking the yellowfin and albacore together the distribution of the catch per unit of effort expressed for convenience in terms of metric tons per thousand hooks, for the years 1964 and 1965, are given in Figures 6 and 7.

It is worth noting that whereas there are latitudes and longitudes of peak catch and effort, the corresponding catches per unit of effort by latitude and longitude do not show such peaks. Griffiths and Nemoto drew attention to the fact that almost no fishing was done between longitudes 62° and 63°W by the Venezuelan-Japanese vessels whose data they used. Since Las Aves submarine ridge lay between these two longitudes a connexion was suggested. Later data from the fleet as a whole have much reduced this negative correlation leaving its original occurrence still unexplained.

6 CONCENTRATION OF FISHING EFFORT

It is often useful to determine whether a fishing fleet can consistently find greater than average densities of fish. This can be done by computing for any given area and time period two indices of apparent abundance, provided the data from the fishery are known by appropriate subareas, such as 1° rectangles. The unweighted index (total catch ÷ total effort) is divided by the weighted index (total of the catches per unit effort of all the subareas ÷ number of subareas). This ratio has a mean value of unity if fishing is random with respect to the density distribution of the fish.

The data from the Venezuelan fishery fall into two categories, as pointed out in the section on the distribution of catches, but the concentration index is, at least theoretically, unaffected whether the catch rates are in terms of numbers or weight of fish, although this assumes that the size composition of the stock is more or less uniform throughout the area of the fishery.

The index has been computed and plotted for the years 1960-1965 (Figure 8). This shows that the original Venezuelan-Japanese vessels had some ability to concentrate their fishing effort (though Griffiths and Nemoto showed that the slope of the regression line between the two indices did not differ significantly from 1.0). The fleet as a whole, however, has a significantly lower ability to concentrate its effort and indeed appears to do worse than random, which may merely reflect its general inability to seek out tuna far from land owing to the relatively small radius of action of most of the vessels, unless, of course, the above-mentioned assumption regarding uniform size-composition does not hold. Also the longliners mostly catch deeper-swimming fish and may therefore have almost no signs at the sea surface of the fish they seek to capture. This may explain the fleet's indifferent ability to concentrate its effort.

7 FURTHER CONSIDERATIONS OF THE FISHERY

Wise and Le Guen favoured the view that the stocks of tuna of the eastern Atlantic are separate from those of the western Atlantic. Their data are so much more complete than those of the Venezuelan fishery that they may be taken as better describing the status of the stocks in the Western Atlantic Ocean (leaving aside now those of the Eastern Atlantic). Tunas are migratory fish and Wise and Le Guen's data, as well as our own, support this fact. Nevertheless we know very little of the factors that determine these migrations. The outflows of the Amazon and Orinoco rivers are probably important, especially towards the end of the rainy season (November). About one fifth of the world's flowing fresh water is in the Amazon drainage basin and the drainage basin of the Orinoco is also considerable. The effluent of these two rivers is carried northward and enters the Caribbean north of Trinidad,

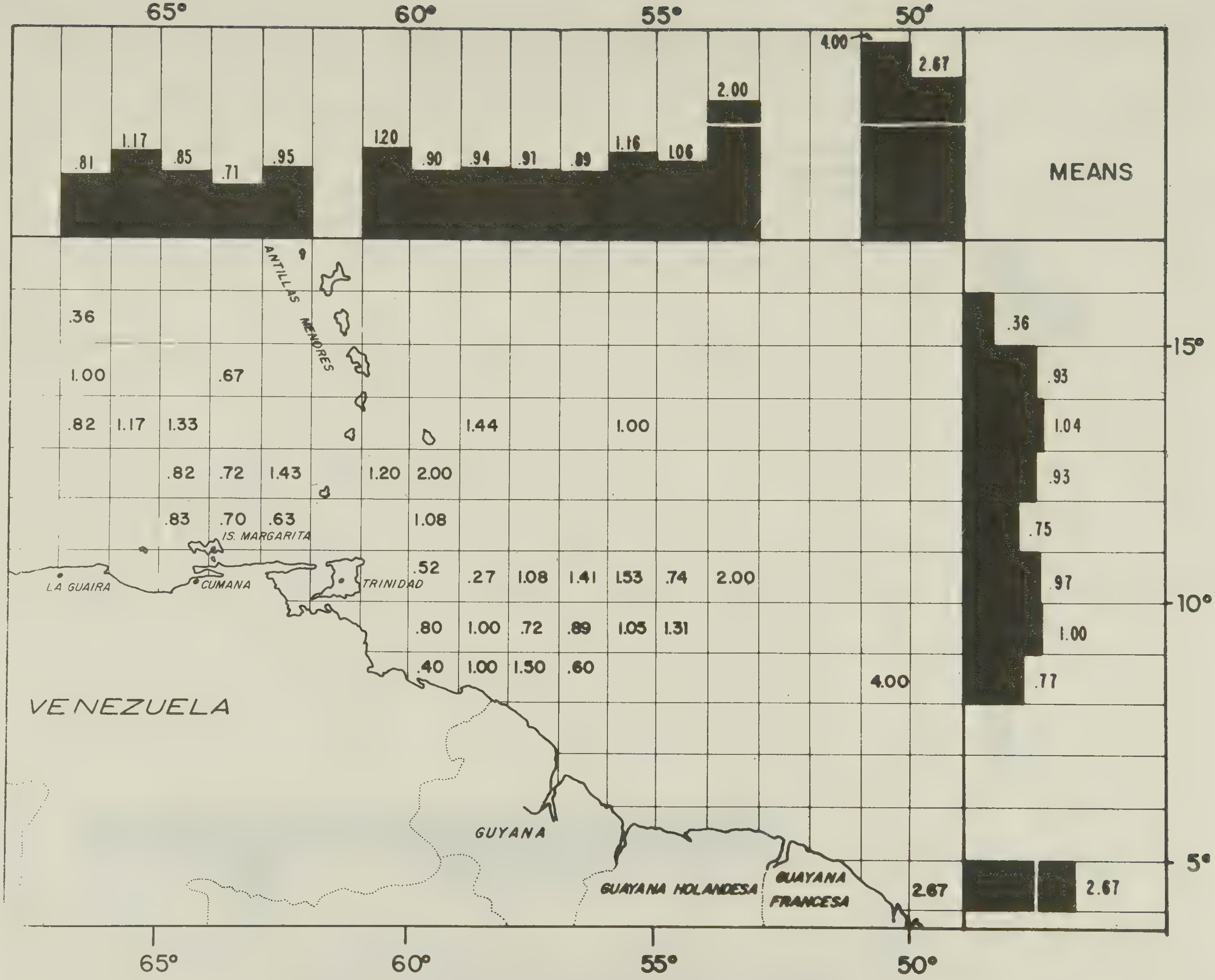
65°
60°
55°
50°
MEANS
.81
1.17
.85
.71
.95
1.20
.90
.94
.91
.89
1.16
1.06
2.00
4.00
2.67
ANTILLAS MENORES
.36
1.00
.67
.82
1.17
1.33
1.44
1.00
.82
.72
1.43
1.20
2.00
.83
.70
.63
1.08
IS. MARGARITA
.52
LA GUAIRA
CUMANA
TRINIDAD
.27
1.08
1.41
1.53
.74
2.00
.80
1.00
.72
.89
1.05
1.31
.40
1.00
1.50
.60
4.00
VENEZUELA
GUYANA
GUAYANA HOLANDESA
GUAYANA FRANCESA
2.67
.36
15°
.93
1.04
.93
.75
.97
10°
1.00
.77
5°
2.67

Fig. 6 The distribution of catch per unit of effort, expressed for convenience as metric tons per thousand hooks, and the mean values by degrees of latitude and longitude, for the Venezuelan tuna fishery for 1964

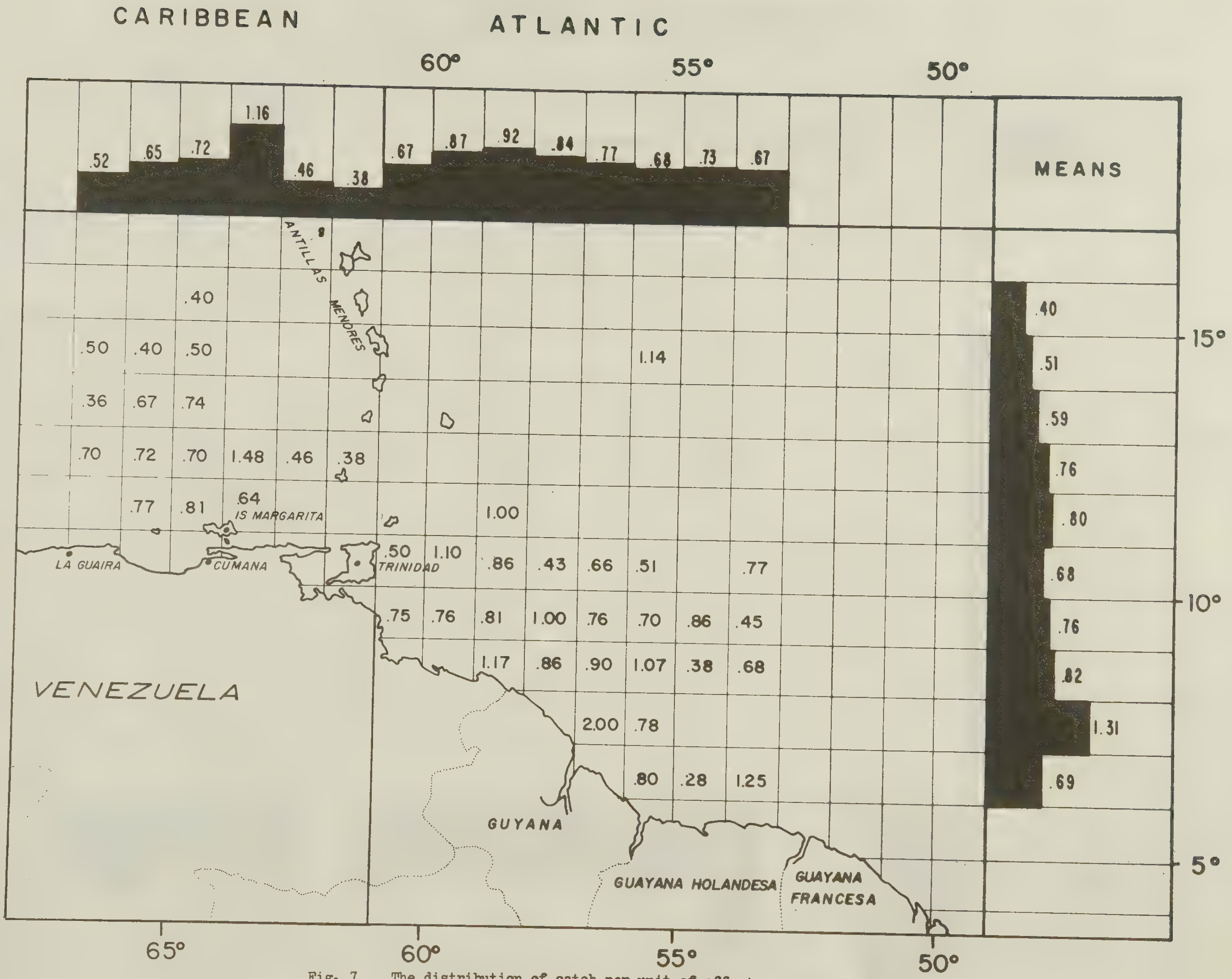
CARIBBEAN
ATLANTIC
MEANS
60°
55°
50°
65°
15°
10°
5°
.52
.65
.72
1.16
.46
.38
.67
.87
.92
.84
.77
.68
.73
.67
.40
.51
.59
.76
.80
.68
.76
.82
1.31
.69
ANTILLAS MENORES
.40
.50
.40
.50
1.14
.36
.67
.74
.70
.72
.70
1.48
.46
.38
.77
.81
.64
IS MARGARITA
1.00
.50
1.10
.86
.43
.66
.51
.77
LA GUAIRA
CUMANA
TRINIDAD
.75
.76
.81
1.00
.76
.70
.86
.45
1.17
.86
.90
1.07
.38
.68
2.00
.78
.80
.28
1.25
VENEZUELA
GUYANA
GUAYANA HOLANDESA
GUAYANA FRANCESA

Fig. 7 The distribution of catch per unit of effort, expressed for convenience as metric tons per thousand hooks, and the mean values by degrees of latitude and longitude, for the Venezuelan tuna fishery for 1965

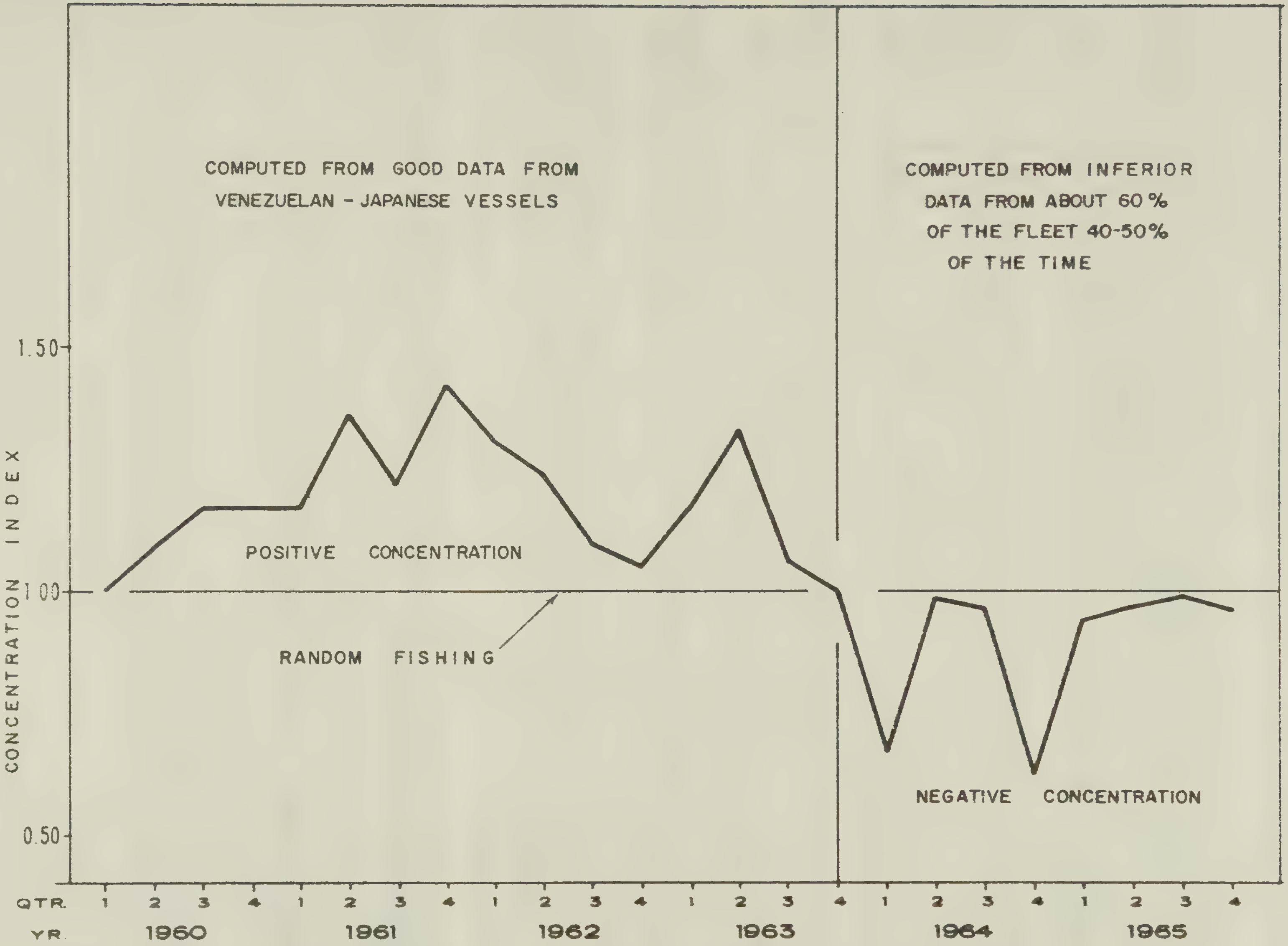

Fig. 8 The mean concentration index by quarters for the years 1960 to 1965 for the Venezuelan tuna fishery. The values for 1964 and 1965 may be artificially low (see text). A ratio of unity signifies random distribution of effort with respect to that of stock density

though some from the Orinoco passes westward of Trinidad (Parr, 1937). Geography and geostrophic forces prevent it from coming close to the north coast of Venezuela.

Not much is known of the effect of salinity on tunas, but it is generally far less obvious than that of temperature. Rosa and Laevastu (1962) give the preferred temperature ranges for yellowfin and albacore and in general these correspond to normal temperatures in the Caribbean and Western Atlantic. But off the northeastern coast of Venezuela there is a quite pronounced seasonal upwelling (Gade, 1961; Ljoen and Herrera, 1965), such that sea surface temperatures near the coast may fall to as low as 21°C which approaches the limiting value for commercial concentrations of yellowfin in the Pacific Ocean (Blackburn, 1965). We do not know how much this upwelling (strongest between December and April, but occurring sporadically through the year) affects tuna abundance off northeastern Venezuela. The matter bears further study.

The Venezuelan fleet, and perhaps most of the others, fishes without reference to thermocline depth. So far as I know no work has been done on the relationship between thermocline depth and longline fishing success. It is well known that the catch rates of the several hooks on each catenary of the longline differ noticeably, certain species being caught more frequently than pure chance would allow on certain hooks. Since the hooks cover an appreciable depth range, the deepest being perhaps as much as 50 m deeper than the shallowest, it is possible for hooks on the same longline unit to be on both sides of a thermocline. Very little work on the effect of hook depth has been carried out, as far as I know, and appears worthwhile doing.

Nemoto (personal communication) has suggested, from a study of the proportion of "still live" fish in the catch at the moment of boarding and, much less critically, the proportion of "long dead" fish, that most of the fish take the hooks during setting and boarding the longline; in other words, when the hooks are in motion. This suggests that the fishery might benefit from some experimental fishing to compare the catch rate with the duration of the set.

The Venezuelan vessels bring tuna to port gutted, so that it has proved practically impossible to determine seasons of sexual maturity and likely spawning areas. Nothing is known of the distribution of eggs and larvae of tunas in area of the Venezuelan fishery. For the same reason we know nothing much about the tunas' diet in this region.

There is not much doubt that the comparatively high price of tuna on the protected Venezuelan market tends to maintain an inadequate and inefficient longline fleet and to prevent substantial improvements. Nor does the relatively depressed state of the stocks, even in the Western Atlantic area, provide a basis for such improvements whatever the circumstances. The case for regulation of the tuna resources of the Atlantic is now weighty.

8 BIOMETRIC STUDIES

These were started tentatively with a view to determining whether Caribbean stocks differed significantly from those of the Western Atlantic Ocean. This line of work has not been developed yet but a few preliminary results are available.

The following measurements have been made on samples of yellowfin and of albacore though presentable results are only available for yellowfin:

standard length (snout to posterior edge of caudal fluke)

head length

snout to insertion of first dorsal fin

snout to insertion of second dorsal fin

snout to insertion of anal fin

pectoral insertion to insertion of first dorsal

greatest body length

pectoral fin length

first dorsal fin length

second dorsal fin length

anal fin length

eye diameter

number of dorsal fin spines

number of dorsal finlets

number of anal finlets

Parameters were computed of the regressions of dimensions 2 to 6 on standard length. The measurements are from thirty specimens from the Caribbean, and seventy-five from the Atlantic. The data indicated no significant difference between sexes.

The values for the regression parameters (slope "b" and intercept "a") are given in Table I together with some given by Schaefer (1948) for eastern Pacific yellowfin. Schaefer, however, used the total length as an independent variable which would make his regression slope values relatively lower, in a fixed ratio generally speaking, since there is normally a linear relationship between total and standard length. In this respect Schaefer's value for the regression coefficient between total length and pre-first dorsal length is relatively higher than our values in spite of our use of the shorter standard length.

TABLE I

Comparison of regression parameters for various morphometric characters of yellowfin from the Caribbean, the Western Atlantic and the Eastern Pacific (from Schaefer, 1948, based on total length not standard). Measurements are to fin insertions in centimetres

Regression on Standard length (except for Eastern Pacific)	Caribbean Sea		Western Atlantic Ocean		Eastern Pacific Ocean	
	b	a	b	a	b	a
Head length	+0.245	+2.79	+0.269	-0.300	+0.2350	+3.78
Pre-dorsal length	+0.247	+6.71	+0.270	+4.565	+0.2635	+3.15
Pre-2nd dorsal length	+0.508	+4.55	+0.527	+1.881	+0.4768	+4.94
Pre-anal fin length	+0.580	+2.18	+0.586	+0.642	+0.5351	+5.38
Length from 1st dorsal to pectoral	+0.173	-2.45	+0.175	-2.554	+0.1469	+4.20

There seem to be no significant differences between Atlantic Ocean and Caribbean Sea samples though strict statistical comparisons have not been made. The slopes (b) for head length, snout to first dorsal, and snout to second dorsal, on standard length are, however, noticeably higher for the Atlantic fish than for the Caribbean.

These studies seem worthwhile continuing and expanding, especially since there is evidence, only recently available (Baudin-Laurençin and Marchal, 1968), to show that many of these relationships are curvilinear over the whole length range of the yellowfin tuna, and we have tentatively compared Schaefer's data, based on fish of a mean length of about 95 cm, with ours, based on fish of a mean length of about 120 cm.

The importance of the length-weight relationship in fishery studies is well known. However, it has proven more or less impossible, so far, to obtain whole specimens from the commercial catches of the Venezuelan fleet, but a provisional relationship for gutted specimens has been obtained for 111 yellowfin. No obvious differences between sexes or areas were found. The provisional equation is:

$$\underset{g}{W} = (0.00000374)\ \underset{mm}{L}^{3.353}$$

9 OTHER SCOMBROIDS

There are three other scombroids which are of commercial interest. The "cabañas" are in one group in the official statistics but are made up of Sarda and Auxis, the proportions being unknown and variable from area to area and time to time. They are caught by baited hooks ("cordel") and gill nets mainly, the chief area being eastern Venezuela.

The catches classified under "carite" are three species of Scomberomorus. The two most abundant are S. maculatus and S. cavalla. These "carites" are also taken chiefly by "cordel" and gill nets. Unlike the "cabañas" these are taken along the whole of the coast of Venezuela, though the western region and eastern region predominate over the remainder.

The catches of "cachorreta" (Scomber colias) are much smaller than those of "cabaña" and "carite", but this fish is often very abundant locally and the young ones are taken quite effectively by beach seines. The older ones are more usually taken by baited hook ("cordel") and probably in some gill nets.

Table II shows the catches in metric tons and the corresponding values, in thousands of bolivars, of these three kinds of fish.

The "cabañas" are sold fresh locally or salted. They are sometimes canned as "tuna" or "bonito".

TABLE II

Catches and values of other scombroids of actual or potential commercial interest

YEAR	CABAÑA (Sarda, Auxis)		CARITE (Scomberomorus)		CACHORRETA (Scomber)	
	Metric tons	Bolivars (1000's)	Metric tons	Bolivars (1000's)	Metric tons	Bolivars (1000's)
1963	1 002	784	2 989	4 409	209	177
1964	1 353	1 209	3 897	5 606	217	166
1965	1 763	1 498	3 225	4 954	406	385
1966	1 434	1 198	3 462	5 591	269	234
1967	1 070	880	3 028	5 035	372	286

The "carites" are an important element in the fresh-fish diet and in the restaurant trade. Otherwise they are salted for later sale. Some preliminary attempts at industrialization have been made, one company producing smoked fillets.

The "cachorreta" is sold fresh mainly but is sometimes canned or filleted. It is known to be very abundant at certain times and places and gives every appearance of being greatly underfished.

These three kinds of scombroids all seem to have considerable potential, something that can hardly be said for the Thunnidae.

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THE MOLLUSCAN RESOURCES OF THE GULF OF MEXICO

by

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Gulf Coast Research Laboratory
Ocean Springs, Mississippi
U.S.A.

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4	REFERENCES	115

1 INTRODUCTION

The molluscan resources of the Gulf of Mexico are not well known. However, even on the Northern Gulf Coast of the United States there seems to be a lower rate of usage by man than the productivity of the area can support. Some day we may speak in terms of energy and calories involved.

My remarks are not as firmly based as I should like, because we are in a new field of appraisal. Nevertheless, that gives me hope because, as has been pointed out by Taylor (1951, p. 319), our great fisheries grow and expand until such time as the demand outstrips the supply; then man turns to some other equivalent fishery resource. I have seen such things happen. Essentially Dr. Taylor is correct. This does not mean, of course, that the Earth is not a finite body and that it can be expected to give its benefits forever with a largesse which has no limit, but it does mean that the use of marine resources in this part of the world can be expanded.

With these general concepts in mind I shall discuss the present production of the molluscs of the Gulf of Mexico and possible resources now unused, with some reference even if only by analogy to the Caribbean Sea. We may expect that molluscs as food in this area in the future may exceed anything we have in mind now and the increase will be related to the increase in knowledge of these animals.

2 PRESENT UTILIZATION OF GULF OF MEXICO MOLLUSCS

2.1 Oysters

The greatest oyster production in North America was in 1880 when Chesapeake Bay alone produced 70 million kg of oyster meats. That body of water then produced more oysters than all the rest of the world. Ever since then the oyster production of the United States has declined until now it is less than it was in 1860. The greatest oyster production of the Atlantic Coast states of the United States state by state was in 1911, whereas the general peak year on the Gulf of Mexico was 1939. Pollution and industrialization of the Atlantic coast came earlier than it did on the Gulf Coast.

Table I shows that the west coast of Florida had a great decline in oyster production in the years 1941 to 1959 and then a great increase. Alabama has declined considerably in recent years while Mississippi has increased considerably in recent years. Louisiana has had relatively stable high production. It is the state with the vast influx of the Mississippi River. We have begun relatively recently to apply the knowledge of biology to oyster culture in all of these states. Thus, we have raised oyster production, but sewage pollution is cutting into production in Mississippi and in fact in every state of the Gulf Coast except Louisiana, where oyster beds are down in the marshes far from the large cities.

4.29

TABLE I

Annual Production for Three Periods of Oyster Production for the States
of the United States Bordering the Gulf of Mexico
Figures are in pounds
1 kg = 2.2 lb

Period	Florida	Alabama	Mississippi	Louisiana	Texas
1. 1887-1940	1 394 000	939 000	4 108 000	6 252 000	1 514 000
2. 1941-1959	859 000	1 385 000	698 300	9 426 000	691 000
3. 1960-1965	3 334 000	769 000	2 887 378	9 917 000	2 569 000
Factor of Change	3.88	0.56	4.11	1.05	3.72

From 1962 until 1966 the east coast of Mexico, according to Biologo Juan Luis Cifuentes, produced an average of 19 200 metric tons of oysters in the shell a year. This amounted to about 1 296.3 metric tons or 1 296 300 kg of oyster meats. This included the states of Tamaulipas, Veracruz, Tabasco, Yucatán and Quintana Roo. When these figures are added to Table I we note that the total Gulf production under present conditions has amounted to approximately 10 148 899 kilograms. This figure is greater than at any time in history possibly because the bays are becoming hyperfertilized. Furthermore, there seems to be little doubt that production can be increased by improved methods of oyster culture (Cf. Gunter and Demoran, in press).

In spite of these remarks I am not hopeful about the long range future of the estuaries as the coasts become industrialized and densely populated. This means we must either move out of the estuaries for our molluscan foods or we must learn to purify or depurate them at a much cheaper price. This means further that the relative importance of oysters as compared to other molluscan foods will decline.

I have given emphasis to oyster production because it is the most highly utilized mollusc of the Gulf and it is a point of reference in speaking of the other molluscs and those that may be utilised.

2.2 The Molluscan Catch of the Gulf of Mexico Other than Oysters

Only the 1966 catch (Lyles 1968) is reported and the statistics are given in Table II. My own state produced nothing; Louisiana produced 1 000 lb of squid and Alabama produced 8 000 lb (3 640 kg). Comparatively speaking, Texas and west Florida were large squid producers. Squid, in the amount of 61 000 lb (27 700 kg) in 1966, are produced more abundantly than any other mollusc in the Gulf of Mexico except oysters. This is followed by 51 000 lb (23 180 kg) of conchs from Florida. Florida also produced 9 000 lb (4 100 kg) of bay scallops. Thus, Florida led the non-oyster mollusc production in 1966 with a total of 93 000 lb (42 270 kg). The total production of the whole Gulf Coast of the United States in 1966 was 55 000 kg of non-ostreid mollusc meat or equal to about 0.7 percent of the oyster production. This does not include the Mexican or Cuban production because I do not have figures.

The names of molluscs in statistical reports are even more indefinite than those of the fishes. In Table II the conchs are made up of several species of Strombus, Busycon, and probably Fasciolaria. The bay scallops are Pecten. The squid are said to be Loligo pealei, but the inshore Lolliguncula brevis is easier to catch and they are eaten. The quahog, which in Florida is called the hard clam, belongs to the genus Mercenaria. On the Florida west coast it has varied in production from 225 973 lb (102 720 kg) of meats in 1962 to 3 475 lb (1 580 kg) in 1966, an average of some 80 000 lb (circa 36 000 kg) production a year. However, the figures for species may not be accurate because the low salinity clam, Rangia cuneata, is also eaten and some people think they are cherrystone clams. Biologo Juan Luis Cifuentes has informed me that this clam is also used in Mexico. The Mexicans also make use of squid, octopus, Strombus, and the marine clam, Chione.

The present use of all species of clams, whelks and all other molluscs in the Gulf of Mexico amounts to about 1 percent of the mass of oysters used. This great disproportion is probably not due to differences in species mass of the various molluscs present.

TABLE II

Production of non-ostreid molluscs on the Gulf Coast of the
United States in 1966 by states
Figures are in pounds
1 kg = 2.2 lb

	West Florida	Alabama	Mississippi	Louisiana	Texas	Mexico
Conchs	51 000					Used
Bay Scallops	9 000					
Squid	30 000	8 000		1 000	22 000	Used
Quahog	3 475					

Various conchs have been canned in South Florida and even their juice was canned and called conch-tail. The beautiful little coquinas of the beach also have been canned. *Donax variabilis* is the species used. The most complete paper on this clam is by Loesch (1957). These little animals are extremely abundant and I have seen the Texas beaches at night almost completely covered, shining ahead as far as the eye could see as if the beach had been enamelled. The clams are only about an inch long. They have to be kept in wire baskets suspended in sea water to permit them to cleanse themselves of sand. Then they can be cooked and the meat and juice easily separated from the shell by simple agitation and pouring off the natant material. The product is delicious but the process of preparing it is tedious and not adaptable to commercial operations. And so the canning of the coquina was an abortive effort which will probably not be revived. It will remain a gourmet food.

The oyster borer, *Thais haemastoma*, a prosobranchiate gastropod, has been used on the Louisiana coast. It is related to *Murex*. *Thais* is a very serious predator on the oyster and someone thought of canning it with the hope that commercial use might lead to some reduction in numbers. However, the animals taste very strong and they have a particular odour which may be connected with the purpurin for which the muricids are famous. In any case they simply cannot be eaten together in large amounts. Nevertheless, if people were taught how, this animal could be utilized as food. One or two put into a gumbo or soup gives it a delicious flavour. However, trying to eat them alone is comparable to trying to eat a pot of pure garlic.

One other mollusc has been introduced in the commercial market recently in western Florida and that is the beautiful shiny, thin-shelled clam, *Macrocallista nimbosa*. In offshore salty waters at a depth of 10 fm this clam is extremely abundant and the flavour is excellent.

3 POSSIBLE FUTURE USES OF EDIBLE MOLLUSCS OF THE GULF OF MEXICO

The Virginia oyster, *Crassostrea virginica* (Gmelin), is the preponderant molluscan food of the Gulf coasts of the United States and Mexico. Quite probably a similar situation holds true in Cuba, with the exception that the oyster there is possibly *C. rhizophorae*. Possibly *Ostrea frons* is also present around the shores of the Caribbean Sea growing on mangrove roots. Furthermore, there are *Crassostrea* sp. commercially produced in Columbia where they are being studied by Dr. Alejandro Ciardelli-Fadul. These oysters are probably *C. virginica*. Other areas around the Caribbean deserve attention. The whole Gulf Coast and the Caribbean area could increase its oyster production by better conservational efforts utilizing knowledge we already have. For instance, I believe that the oysters in Mexico would produce more if they were not fished the year round. South of the Tropic of Cancer the seasonal changes are certainly not great in the temperature range but they are great in regard to rainfall. There are also come simple engineering works such as the diversion of the Rio Tampico into the Laguna de Tamiahua that should enhance not only the growth of oysters but of shrimp, mullet, and several other marine fishes. But a thorough survey of the whole region should be made before any extensive action is taken.

Before we leave the oyster potentialities let us note that the U.S. Bureau of Commercial Fisheries exploratory vessel, the OREGON, once inadvertently caught a large trawl full of oysters from 215 fm depth off the coast of French Guyana. Some of these were sent to my Laboratory. They belong to the species *Pycnodonte thomasi*. Thus we learned that this genus must exist in reefs, a fact quite unknown before. If the concentration is great, some day they may be dredged.

4.29

TABLE III

List of molluscs of use or potential use as food organisms

- Gastropoda
  - *Strombus alatus* Gmelin 1790
  - *Polinices duplicatus* Say 1822
  - *Sinum prespectivum* Say 1831
  - *Phalium granulatum* Born 1780
  - *Murex fulvescens* Sowerby 1834
  - *Thais haemastoma* Linné 1767
  - *Cantharus cancellarus* Conrad 1846
  - *Busycon perversum* Linné 1758
  - *Busycon spiratum* Lamarck 1816
  - *Fasciolaria hunteria* Perry 1811
  - *Oliva sayana* Ravenel 1834
  - *Cancellaria reticulata* Linné 1767
- Opisthobranchia
  - *Aplysia willcoxi* Heilprin 1886
  - *Armina tigrina* Rafinesque 1814
  - *Scyllaea pelagica* Linné 1758
- Cephalopoda
  - *Loligo pealei* LeSueur 1821
  - *Lolliguncula brevis* de Blainville 1823
  - *Octopus vulgaris* Lamarck 1798
- Bivalvia
  - *Anadara brasiliana* Lamarck 1817
  - *Anadara ovalis* Bruguiere 1792
  - *Noetia ponderosa* Say 1822
  - *Brachidontes recurvus* Rafinesque 1820
  - *Modiolus demissus* Dillwyn 1817
  - *Atrina seminuda* Lamarck 1819
  - *Atrina serrata* Sowerby 1825
  - *Aequipecten irradians* Lamarck 1819
  - *Crassostrea virginica* Gmelin 1792
  - *Polymesoda caroliniana* Bosc 1801
  - *Lucina floridana* Conrad 1833
  - *Dinocardium robustum* Solander 1786
  - *Laevicardium laevigatum* Linné 1758
  - *Chione cancellata* Linné 1767
  - *Dosiria discus* Reeve 1850
  - *Macrocallista nimbosa* Solander 1786
  - *Mercenaria mercenaria* Linné 1758
  - *Donax variabilis* Say 1822
  - *Tagelus plebeius* Solander 1786
  - *Rangia cuneata* Gray 1831
  - *Spisula solidissima* Dillwyn 1817

Other molluscan species are potential food organisms. Some of these have been mentioned. The list given in Table III comprises three cephalopods, twenty bivalves, three opisthobranchs and eleven gastropods. It is based upon Moore's (1961) paper on the marine and brackish water molluscs of Mississippi and does not include such things as the nearby *Melongena corona* of western Florida, *Pleuropocra gigantea* or the calico scallop. And certainly there are dozens of other edible molluscs to the south.

The list is based almost purely on size because virtually all molluscs are good to eat, with the exception of those which have fed upon poisonous dinoflagellates such as the organism causing the red tide in Florida (Cf. Gunter *et al.* 1948). We do not eat the very smallest species, although it can be done. My respected professor, Dr. E.J. Lund, was at the Stazione Zoologica di Napoli during the days of its founder, Anton Dorhn. He told me that people went out with little dredges and fine mesh nets and dragged around for an hour or so and came back with a litre or so of small molluscs, both gastropods and pelecypods, numbering dozens of species and a few thousand specimens. These were boiled up for broth and soup.

Of the listed species some are present in enormous numbers. A few words about some of these should illustrate the point.

Macrocallista nimbosa extends in a fairly wide bed or band in about 10 fm of water for miles and miles along the Florida, Alabama and Mississippi coasts. There is no question of pollution here. Off Cape Canaveral, Florida people who observed the calico scallops from miniature submarines refuse to give estimates of numbers, except in millions and to say that it is the greatest potential stock in the world. At present up to 40 bu are being taken in 30-minute drags.

Off the western Louisiana coast there is an area of several square miles where Murex fulvescens and Strombus alatus are so abundant that the shrimp fishermen trawl there with difficulty or not at all. The abundance of these gastropods is enormous. Very little is known of the abundance or concentrations of other gastropods listed. I have included some opisthobranch snails. No one eats these organisms but I know of no reason why they are not edible, although I know of no great concentration in the Gulf of Mexico. But if the whales of the sea can gather in the pteropods, I do not see why man cannot do so, too, and at least test them for edibility.

The mussels Brachidontes and Modiolus are delicious and they contain a great deal more meat than one would suspect from their internal appearance. At certain times Brachidontes cover oysters and virtually smother them. Further, if mussels can be cultivated in Spain and Portugal they certainly can be cultivated in the Gulf and Caribbean.

There is an area on Padre Island on the Texas coast where there are thousands of Dinocardium shells on the beach. They are so thick that it is impossible for automobiles to pass except at low tide and the area goes by the name of Big Shell. There is also a similar area a few miles away called Little Shell. The beds of Dinocardium which give rise to these shell beds must be immense.

Along the lower Mississippi River there are vast mounds made up of Rangia shells discarded by the Indians who ate the live clams. Today in Louisiana thousands of tons of dead Rangia shells are dredged up every year for industrial use. Live Rangia and probably Polymesoda are present in enormous numbers but they are not used as food, as they are in Mexico and Florida in small numbers.

We have little information concerning abundance of the remaining bivalves given on this list, but if serious and thorough explorations were made it is quite probable that vast conglomerations of edible bivalves in the Gulf and Caribbean region would be found, just as has been recently discovered for Macrocallista and the calico scallop off Florida.

Octopuses probably will not be found in great numbers except around certain reefs, but the Japanese have taught the world how to grow these animals and their methods can be emulated. The trouble is most people do not know how delicious an octopus can be when properly cooked. The same thing holds true for the squid. They are among the most delicate and delicious seafoods in the world.

We know practically nothing about the populations of squids in the Gulf and the Caribbean Sea. However, there are some questions that keep rolling around in my mind. The Japanese catch thousands of tons of cuttlefish every year. There are a good many species of smaller whales in the Gulf of Mexico, some of which are said to live on nothing but cuttlefish. But no cuttlefish has ever been reported from the western Atlantic and the small toothed whales in the Gulf must be living on squid.

I have been impressed with the similarity of organisms in similar ecological situations and I simply do not believe that this double ocean complex, the Gulf of Mexico and the Caribbean Sea, is devoid of a large cephalopod population. I think they must be around somewhere in vast abundance. How to catch them and how to prepare them and convince the human race that they are very fine food are other things that are beyond my provenance.

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ASSESSMENT OF THE YELLOWFIN STOCKS IN THE ATLANTIC OCEAN, 1956-65

by

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1 INTRODUCTION

Previous studies on the stock assessment of the Atlantic yellowfin have been mainly based upon catch statistics of the Japanese long-liners (Nakagome, 1964; Shiohama et al., 1965; Wise and Le Guen, 1966; Le Guen and Wise, 1967; Hayasi and Honma, MS). Recently, French ORSTOM and Japanese Fisheries Agency have advanced surveys on tuna fisheries with the use of pole and line or purse-seine operated along the Atlantic coast of Africa (Postel, 1965; Le Guen et al., 1965; Honma et al., MS). Publication of catch records of the surface fisheries makes it feasible to approach more realistic assessment of the stocks than before.

2 DATA AND METHODS

The Japanese long-liners first exploited the Atlantic tuna in high sea in 1955. Catch records of the fleet have been systematically compiled and published up to 1965 (Shiohama et al., 1965; Japan Fisheries Agency, 1965, 1966, 1967a, b). Korean (south) and Chinese (Taiwan) fleets reportedly exploiting tuna by the method seemed to have landed comparable amounts of catch with that of the Japanese fleet in or around 1967. However, no record has been published yet for the two groups of long-liners. Size composition is fragmental even for catch by the Japanese fleet. Only 22 000 fish were determined by body length for 1955 through 1967 (Honma and Hisada, unpublished).[1/]

Surface fisheries also started in the late 1950s. FAO (1967) showed catch statistics of the yellowfin by country and by area. The catch by France, Spain and Senegal is considered to represent that taken by surface fisheries operated on the waters along the African continent.

The Japan Fisheries Agency has required Japanese fishermen to submit detailed catch records, and furthermore, those working for purse-seine fishery to report measurement of body length and gonad weight. These data have not been finally compiled yet, and include such deficit in that the Japanese boats comprise only limited portion of pole and line and purse-seine fleet exploiting tuna in the Atlantic (Honma et al., MS).

[1/] A part of unpublished paper by M. Honma and K. Hisada is presented to the present symposium under a title "Population structure of the yellowfin tuna in the Atlantic Ocean"

4.4

The French ORSTOM organized fine survey systems at three ports inclusive of Dakar, Abidjan, and Pointe-Noire, since around 1964 (Le Guen et al., 1965; Baudin-Laurençin, 1967). Before commencement of the systematic survey, ORSTOM collected catch records of large-sized pole and line boats having worked for SOVETCO for three seasons between 1961-62 through 1963-64 (Postel, 1965). Since 1964 catch, effort and length data as well as oceanographic cast have been taken by three Centres of ORSTOM at the aforementioned ports. It is possible for the present study to refer annual reports of the surveys in 1966 for the Abidjan Sector and in 1964 through 1967 for the Pointe-Noire Sector. Nevertheless, these data do not cover some portion of boats that landed fish at the other ports. Furthermore, the annual reports do not comprise detailed statistics comparable to those for the Japanese long-liners, which are necessary for calculation of any advanced measures of abundance and effective effort.

Even the simplest model of stock assessment requires catch statistics sufficiently covering the fisheries (Watt, 1956). It makes the study on the Atlantic tuna difficult that available records of both long-line and surface fisheries exclude appreciable portions of fishing activities. Under such situation complicated models are liable to lead one to misunderstanding the stocks. The following four methods were applied for the present study:

(1) Year-to-year changes of length composition

Increased rate of fishing must reduce portion of large-sized and old fish from year to year for the stock without remarkable fluctuation in year-class strength. Examination of length data is possible for catch by long-liners.

(2) Relation between catch per unit effort and amount of cumulative effort within and between seasons

Monthly catch per unit effort must decrease exponentially with amount of effort inserted before the month for a fishery exploiting a single stock during the season as far as all members of the stock enter into the fishing ground at the beginning of season, and the natural mortality does not appreciably fluctuate from month to month, or even if it does, it is negligible compared to fishing mortality. In such cases it is possible to estimate initial stock size index of the season based upon the regression of catch per unit effort on amount of cumulative effort for each season. Relation between initial stock and amount of effort gives idea on effect of fishery upon reproduction of the stock.

Even though monthly stock size fluctuates independently with amount of effort, of course, it is not always possible to deny effect of fishing upon the stock, because such phenomenon can appear if different shoals immigrate the fishing ground during a season. In such cases seasonal mean of monthly stock size indices is an estimate of recruitment for the season.

This method does not always fit for fishes such as tunas movable quite a distance within limited time. However, there is no alternative way for assessment of stocks exploited by surface fisheries, for which data were taken during only three or four years.

(3) Relation between amount of effort and catch in number

Amount of catch in number must increase with amount of effort insofar as the recruitment stays at a level for the fishery that spends several years after its initiation. At the very early years comparable to number of dominant age groups of exploitable stocks, the catch will exceed the equilibrium one. Rate of increase of catch with effort must decrease, approaching to zero, even if the recruitment does not decrease. Amount of effort without appreciable increase of total catch from that gained by less effort is over-investment in harvesting a year-class. It is possible to conclude that recruitment decreases if the increase of effort causes decrease of total catch in number.

Catch by Japanese long-liners is given in number of fish for ten years. The method is applicable for assessment of stocks exploited by the fishery.

(4) Relation between amount of effort and reciprocal of density index

The most urgent problem of yellowfin stock is to determine whether or not the recruitment decreases from year to year. In addition to the method (3), the problem is approached by examining relation between amount of effort and reciprocal of density index of stocks exploited by long-liners. The two measures must be linearly related as far as the recruitment stays at a level, although linearity between the two measures does not always prove constancy of recruitment, especially in the case of the Atlantic tuna fisheries that were initiated quite recently and rapidly increased the effort from year to year.

For the stock assessment, three divisions of areas are adopted on the bases of previous investigations of structure of the yellowfin population in the Atlantic Ocean (Wise and Le Guen, 1966; Honma and Hisada, unpublished). They are: (1) whole of the Atlantic Ocean, (2) equatorial Atlantic, and (3) western and eastern equatorial Atlantic.

3 RESULTS

Length data of catch by long-liners extends between 43 and 184 cm. Dominant length groups appear between 120 and 170 cm that correspond to III through VII ages of the Pacific counterpart (Honma and Hisada, unpublished). The length composition does not differ in range between initial period during 1955 through 1960, and recent years from 1965 to 1967. Modal groups, however, decreased in length from 150-160 cm in the former to 140-150 cm in the latter. The difference in length corresponds to that of one or two ages of the Pacific fish. Change in body length indicates that the long-liners actually lowered survival rate in the exploitable phase.

Catch statistics of the fishery indicate continuous increase of amount of fishing effort invested to exploit tuna inclusive of yellowfin. Effective effort on the species also was on monotonous increase over the ten years. Annual catch increased during the first five years, having reached to a peak of 1 159 000 fish in 1959, and stayed at a slightly low level around 900 000 fish for 1961 through 1965. Stock size index followed similar increase with the catch in the initial four years, probably reflecting expansion of fishing ground, and was on a slight decrease for the recent six years. Density index decreased monotonously since commencement of exploitation, particularly for the recent seven years from 6.6 in 1959 to 0.7 in 1965 at an annual rate of 31 percent.

Since five age groups inclusive of three- through seven-year olds comprise major portion of the catch, old fish in the initial four years might have received much less effect of fishing in their early exploitable phase and then have been more numerous than those recruited since the fishing was established. Furthermore, early expansion of fishing grounds might have permitted the fishery to exploit "new stocks". It is not necessarily possible to conclude, however, that recruitment to the stocks exploited by long-liners over whole of the Atlantic has been on remarkable decrease (Figure 1). The density index also does not prove decrease of the recruitment. Nevertheless, it is to be noted that increase of effort brought no additional, or even slightly less fish since 1961 (Figure 2).

Other two sets of data indicate decrease of the recruitment for the stocks related with those inhabiting the Gulf of Guinea, but not for others. For instance, catch and density index decreased more rapidly than increase of effort in the eastern equatorial area, but not in the western area.

The surface fisheries catch various sized groups ranging from 40 cm to 190 cm in body length, mainly between 50 and 160 cm (Honma *et al.*, MS). Catch per unit effort of either pole and line boats or purse seiners does not decrease between seasons (Table I). This is indicative that recruitments to these types of fisheries have been stable up to 1967.

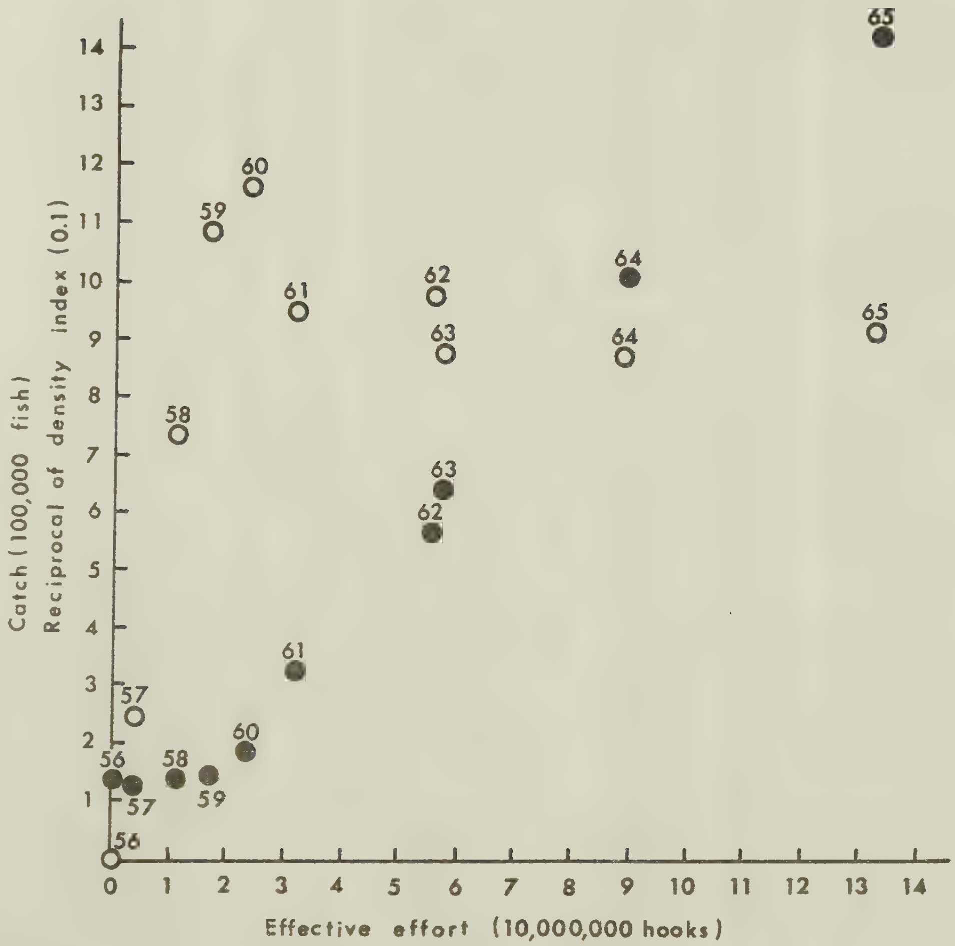

Fig. 1 Relation between effective effort and catch (open circle), and reciprocal of density index (closed circle), Japanese long-liners in the Atlantic Ocean, 1956–65

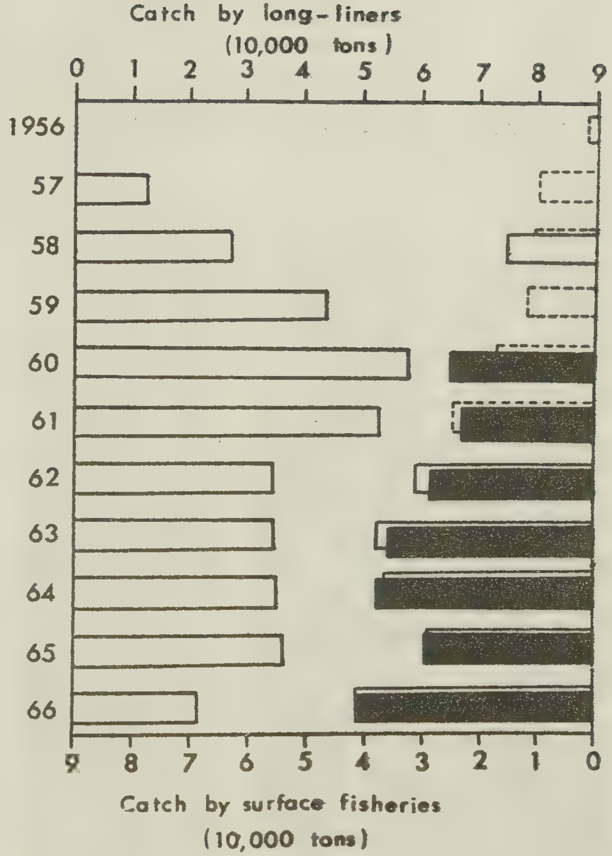

Fig. 2 Annual catch of yellowfin by long-liners (Japan) and surface fisheries in the Atlantic Ocean, 1956–66. Based on data prepared by Hayasi and Honma (MS)

TABLE I

Annual values and annual means of monthly values (in parentheses) of various catch per unit effort of the surface fisheries exploiting tuna in the equatorial Atlantic, 1961-67

Fisheries	Unit of effort	Species	1961	1962	1963	1964	1965	1966	1967
			metric tons						
Pole and line boats of SOVETCO	day-boat on sea	all tuna	2.04 (2.01)	2.33 (2.45)	1.88 (2.01)				
		yellowfin			1.56				
Pole and line boats at Pointe-Noire	day-boat on sea	all tuna				2.9 (2.59)	2.3 (1.64)	3.1 (2.83)	3.8 (4.18)
		yellowfin				2.85	2.05*	2.81*	3.38
Japanese pole and line boats	cruise	all tuna		94.7	79.5	82.4	161.0	77.3	
		yellowfin		40.16	12.54	34.05	42.71	10.18	
Japanese purse seiners	boat-month	all tuna				244.5	350.2	252.4	217.8
		yellowfin				227.7	94.5	185.1	147.3
	day of operation	all tuna				19.6	18.5	24.6	
		yellowfin				18.22	4.99	14.47	

* Based on species composition of annual landings at Pointe-Noire

4 DISCUSSION

Catch per unit effort was on the decrease for stocks exploited by long-liners, especially for those in the eastern equatorial waters during 1956 through 1965, while stayed at a level for those taken by surface fisheries during 1961 through 1967. Similar trend is also found on the catch in weight by these two types of fisheries (Figure 2). If catch made by surface fisheries is combined with that by long-liners in the eastern equatorial waters, hooking rate, and converted catch and effort data do not indicate that the amount of catch would increase with amount of "whole" effort, and that the recruitement has been on the decrease after 1961 (Figure 3). Since the surface fisheries exploit the fish half a year earlier than the long-liners (Honma et al., MS), it is probable to conclude that development of surface fisheries has accelerated decrease of hooking rate of long-liners even though the intensive exploitation by both types of fisheries has not yet destroyed reproduction of the population. The yellowfin stocks must be assessed with data taken from both types of fisheries. Otherwise, complicated calculations are liable to lead one to misunderstanding.

For instance it is surprising to note that the stock size exploited by the surface fisheries has not shown appreciable decrease during 1961 through 1967 in spite of disastrous decrease of hooking rate of the Japanese long-liners, which reflects stock size of parents, for six years up to 1965. Basing on only catch statistics of the long-liners, it is possible to consider inverse correlation between density index in a year and amount of effort in one or more years before the year. Close examination of data indicates that the former is related exponentially with the latter. Thus the density index in the nth year, d_n, is virtually related with cumulative effort in the two preceding years, $f_{n-1} + f_{n-2}$, by either one of the following two equations:

$$d_n = C_n/f_n = B\ a - b\ (f_{n-1} + f_{n-2})\ ,$$

$$\text{or} \quad d_n = C_n/f_n = A.exp.\ -q(f_{n-1} + f_{n-2})\ ,$$

$$\text{where} \quad A = No\ (1-e^{-2M})/(1-e^{-M})\ .$$

At present, these equations are just of empirical natures, and are not proved even from statistical points of view, because the effort and density index changed monotonously for the years under discussion, and thus the correlation itself might have been resulted by chance. Nevertheless, it will provide any meaningful idea when appropriate information would be obtained in future surveys, so as to explain mechanisms underlying the correlation. The calculated catch based upon data obtained for the period of tremendous change of fisheries, of course, are found apart far from the actual ones (Figure 4).

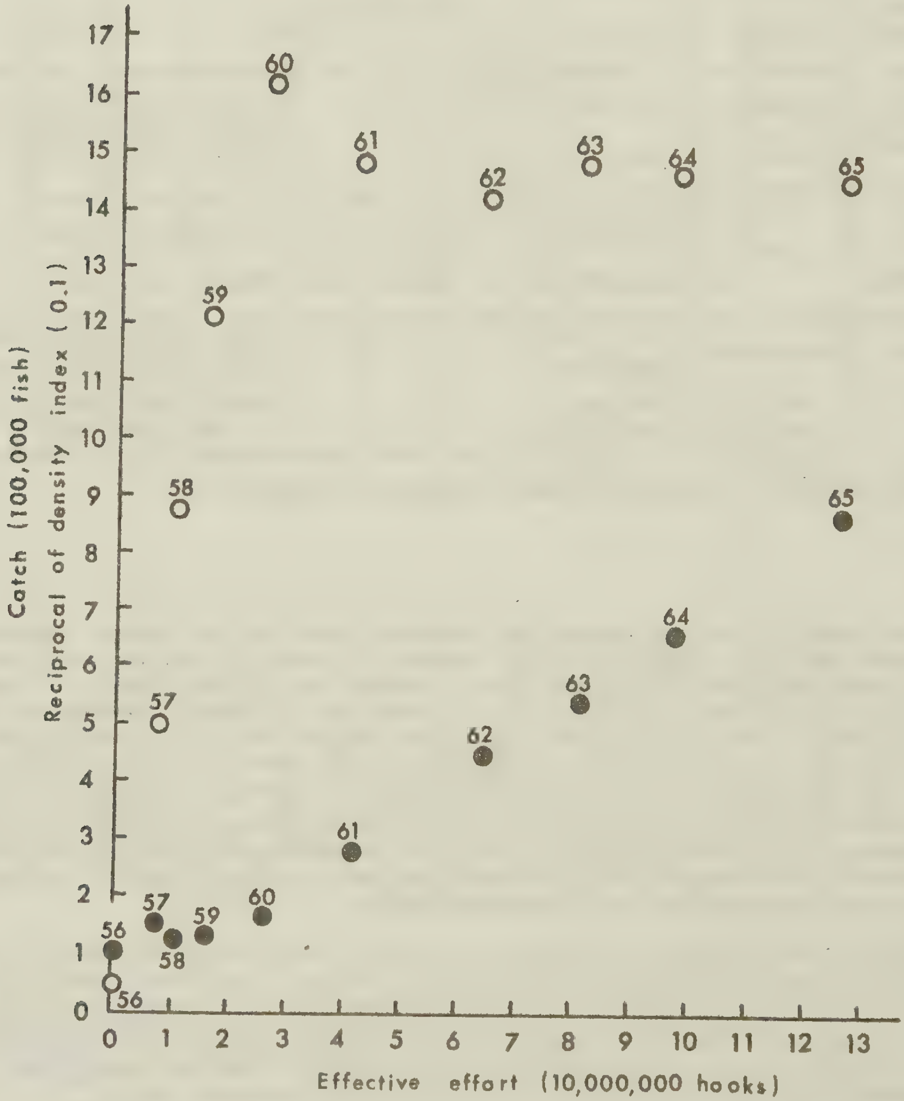

Fig. 3 Relation between effective effort and catch (open circle) and reciprocal of density index (closed circle) of Japanese longliners as well as surface fisheries in the eastern equatorial Atlantic, 1956–65

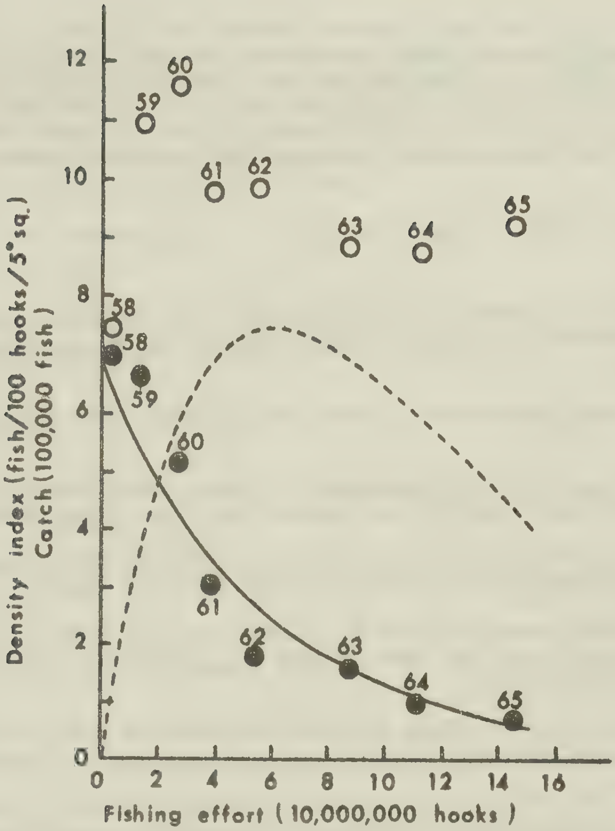

Fig. 4 Relation between density index (closed circle) or catch (open circle) taken by Japanese long-liners in the Atlantic Ocean and cumulative effort in the preceding two years, 1958–65

As to the long-liners it is probable to reduce the amount of fishing effort at or below the maximum level, found in 1964, on which no evidence was obtained to prove decrease of recruitment, as far as the present data were concerned, if average age of fish taken by the surface fisheries is two-year old. A consideration based on some recently presumed values indicates the effort be reduced in order to make the fishery more profitable. According to Suda (unpublished), it may be probable to consider coefficients of natural mortality and catchability as 0.8 and 0.28×10^{-5}, respectively for the fishery that mainly takes four- through eight-age fish. Dealing with the yellowfin taken by long-liners in the Atlantic, Yang *et al.* (unpublished) estimated the growth coefficient in the Von Bertalanffy equation as 0.28. A yield curve prepared on the bases of these figures indicates that the effort in 1964, 90 million hooks, will produce 12.9 units of fish of 66.4 units of weight at a hooking rate of 1.4 units when equilibrium condition would be achieved. Reduced effort of 50 million hooks may still produce 10.8 units of fish of 58.9 units of weight at a higher hooking rate of 2.2 units.

5 RECOMMENDATION ON FUTURE RESEARCH

This consideration indicates that detailed catch records must be compiled for all the fisheries producing appreciable amount of fishes. Required data comprise catch records comparable to that for the Japanese long-liners in the form applicable to detailed calculation, and length composition and gonad index of catch compiled by appropriate spatial and time intervals. It must be noted that, for the surface fisheries, geographical divisions should be one-degree grid, rather than five-degree grid for the fishing grounds, are limited to narrower range than the long-liners.

4.4

In conclusion, it is required to advance studies how to distribute catch quota for each type of fishery. Here it should be taken into account that the long-liners are capable to exploit the yellowfin and other tuna inhabiting offshore waters out of range of the present surface fisheries, and that the surface fisheries can take the skipjack not exploitable by the long-liners. This feature of each type of fishery indicates necessity of advancement of both fisheries under appropriate management, in order to rationally utilize the natural production of the Atlantic Ocean.

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POPULATION STRUCTURE OF THE YELLOWFIN TUNA IN THE ATLANTIC OCEAN

by

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Catch statistics, as well as size of body and gonad index, provide indications on the distributional and migratory features of the yellowfin tuna taken either by longliners or by surface fisheries inclusive of pole and line boats and purse seiners. Fragmental information on juveniles has also been examined to understand the distribution pattern of the population.

Longliners are operated in a wide range of the oceans. Most of the yellowfin taken by this method are in the adult stage (Figure 1). Gonad indices imply that the fish are generally in the feeding (not actually spawning) phase, but may be spawning at times when they are abundantly caught on the fishing ground (Figure 2). The immature fish taken by the method occur in the neritic waters along the African and South American continents. Hooking rates of the fish taken by longliners indicate that the fish is mainly distributed in the South Equatorial Current and related waters. In the northern winter, the rates are found to be high in two separated areas, one in the Gulf of Guinea and the other in the waters extending between the Gulf of Mexico and north-east of Brazil. In spring and summer, the eastern concentration shifts northward and westward, and eventually a continuity is established with the western concentration. The western concentration expands over the waters off the Cape Hatteras through the Caribbean Sea. In autumn, one area of concentration shifts eastward, reaching to the Gulf of Guinea, and the other moves again to the western equatorial waters. Such a shift of an area of high hooking rates implies the presence of two groups of immature and adult stocks exploited by the longliners.

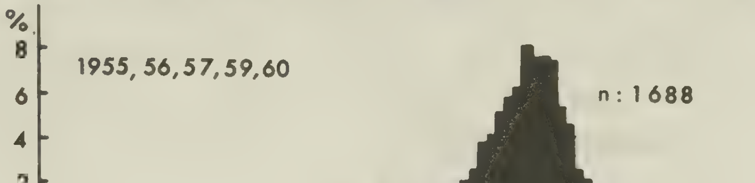
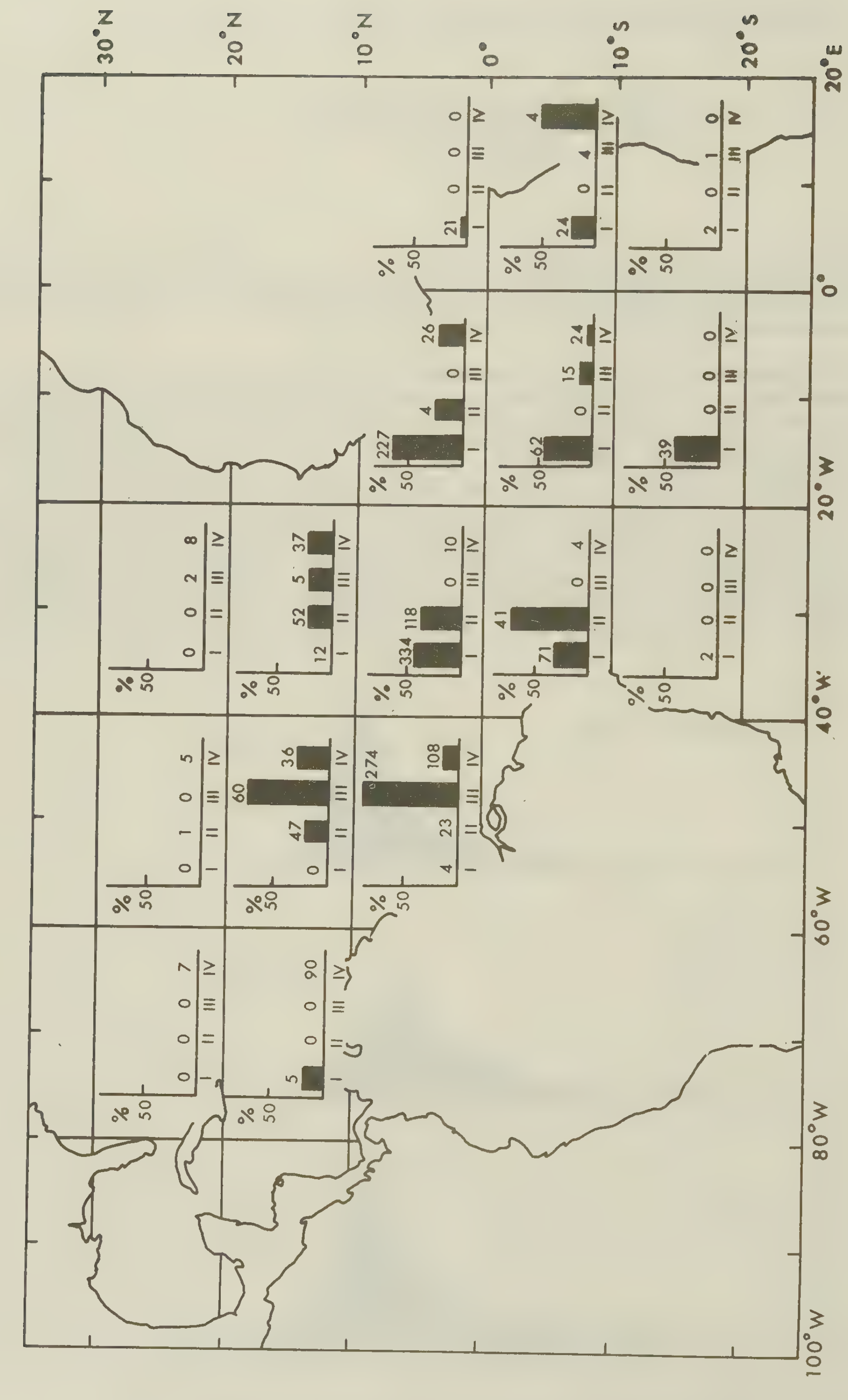


Fig. 1 Length composition of yellowfin taken by Japanese long-liners in the Atlantic Ocean during 1955-60 and 1965-67. Data from Honma and Hisada (unpublished)

4.3


30°N
20°N
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10°S
20°S
100°W
80°W
60°W
40°W
20°W
0°
20°E
%
50
I
II
III
IV
0 0 0 7
5 0 0 90
0 1 0 5
0 47 60 36
4 23 274 108
0 0 2 8
12 52 5 37
334 118 0 10
71 41 0 4
2 0 0 0
227 4 0 26
62 0 15 24
39 0 0 0
21 0 0 0
24 0 4 4
2 0 1 0

Fig. 2 Composition of gonad index of yellowfin taken by long-liners during 3-month periods in 1955-60 and 1965-67. Data from Kikawa (unpublished)

Surface fisheries catch specimens of various size groups, at the young, immature and adult stages mainly in the neritic waters about 200 nautical miles off the 100 m depth contour along equatorial Africa (Figure 3) (Le Guen and Poinsard, 1966; Le Guen *et al.*, 1968). The catch records denote a different migratory pattern from that inferred by examination of the hooking rates. Catch per unit effort is found to increase twice a year, in April through June, and September through November in the north-western part of the Gulf of Guinea, while only once a year during September through November in the south-eastern part (Honma *et al.*, MS). It is known that the location of densely populated areas shift gradually southward during June through April, and rapidly northward during May and June together with shifts of the 24°C water front (Le Guen *et al.*, 1965; Poinsard, 1967). These phenomena suggest that the yellowfin exploited by surface fisheries remain in the Gulf of Guinea the year round.

Plankton net collections indicate that juvenile yellowfin are widely distributed in the waters of the tropical zone and the western part of the temperate zone, in which warm currents prevail. This phenomenon indicates that the yellowfin spawns within a very wide range of the ocean throughout a year, and that different sub-populations, if they exist, would intermingle with each other, and each of them spawn in widely expanded areas giving rise to sub-groups occurring in different areas in different seasons of a year.

All the information shows the difficulty in defining, without logistic contradiction, any group of the yellowfin population reproducing in a particular season of a year and in a particular area of the distribution range, in the way of "races" classically defined by Heincke (1898) for the herring. Conceptions of stock structure other than those defined *a priori* for the species under discussion make it easier to explain the structure of the population. It is assumed that the yellowfin population comprises at least two strata of intra-specific segregation: systematic fractions, and space-time groups. Two systematic fractions actually exist at the adult stage in the Atlantic Ocean; one is distributed in the area extending between the Gulf of Guinea and the northern coast of Brazil, and the other between the northern coast of Brazil and the area off Cape Hatteras (Figure 4). The former must be exploited the year round by surface fisheries at young and immature stages in the waters along equatorial Africa. Each of the eastern and western systematic fractions includes several space-time groups spawned at different seasons of a year and in different parts of the distribution range in the course of seasonal migration. It is not possible yet to determine whether or not the two fractions actually intermingle with each other, and with those occurring in the temperate zone. Advanced types of research such as morphometric, serological and tagging studies are required to examine the above hypothesis on population structure.

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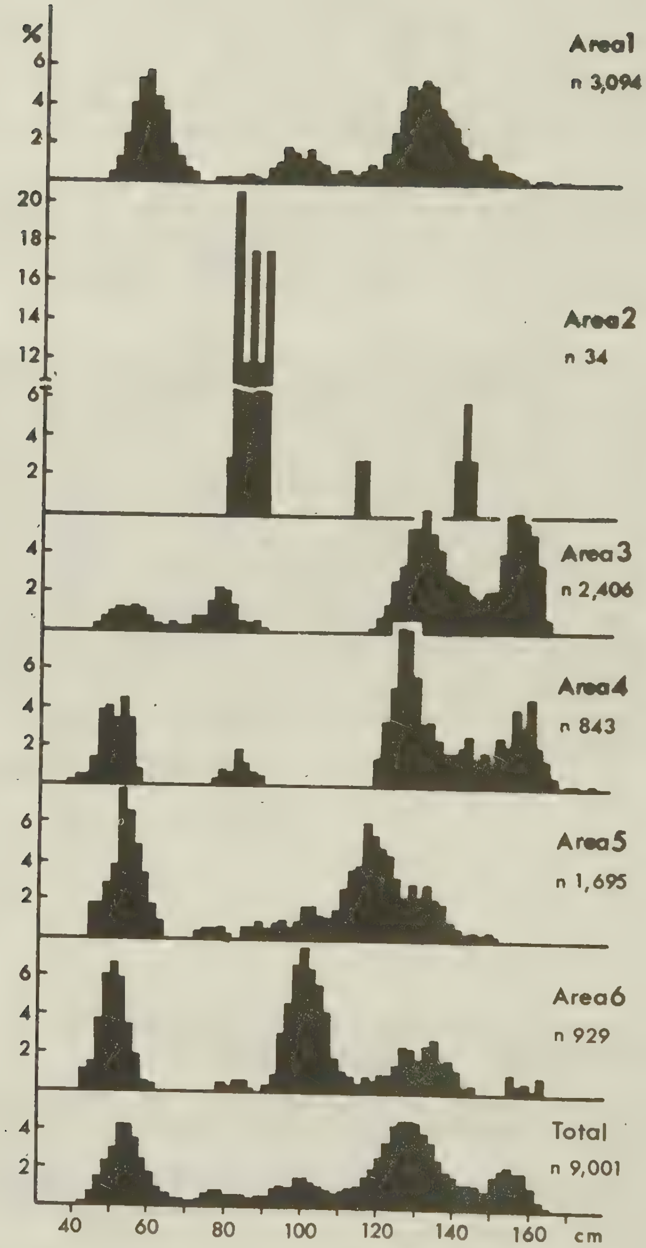
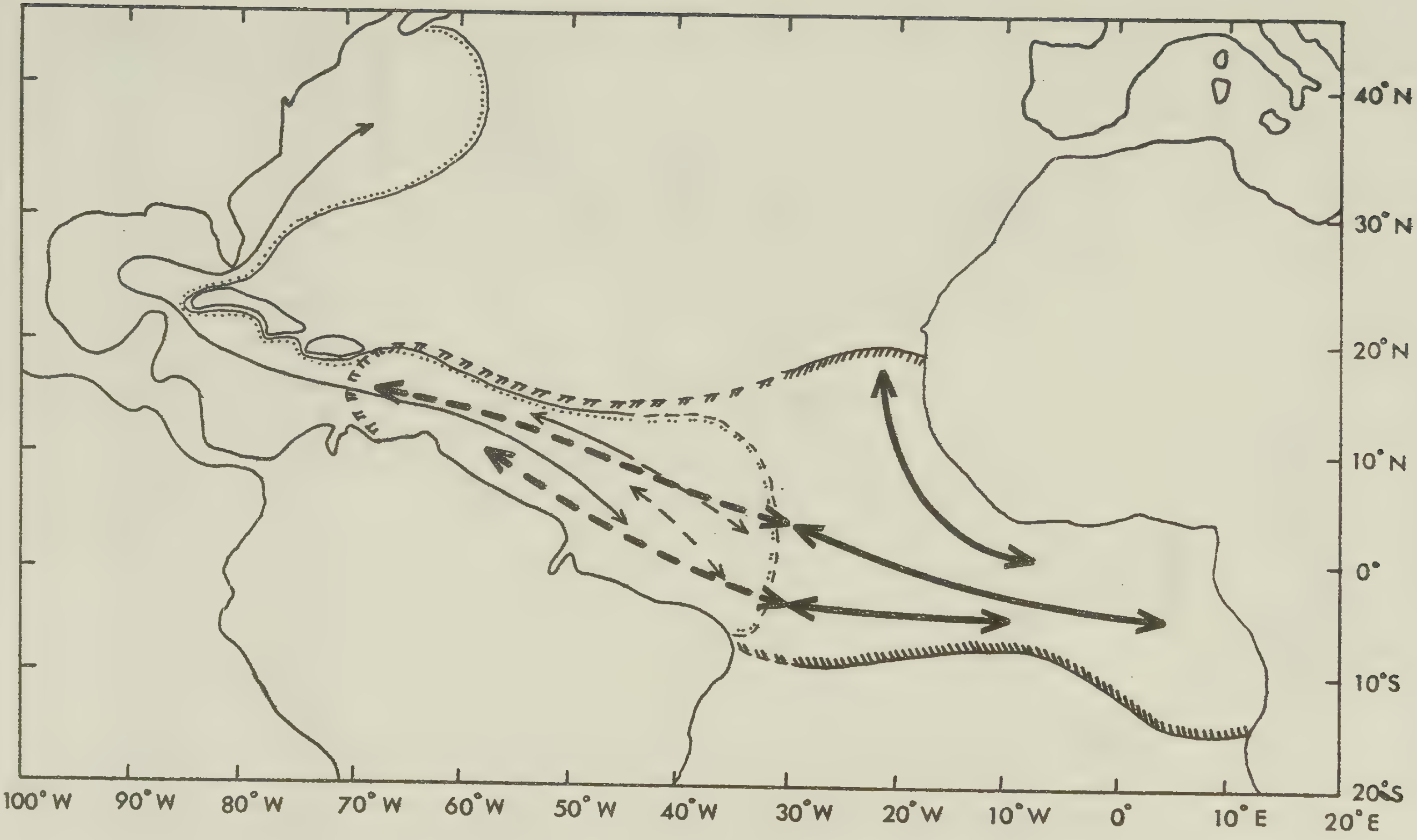


Fig. 3 Length composition of yellowfin taken by Japanese purse-seiners during the period January through July 1967. After Honma et al. (MS)


40°N
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20°S
100°W
90°W
80°W
70°W
60°W
50°W
40°W
30°W
20°W
10°W
0°
10°E
20°E

Fig. 4 Schematic migratory routes of yellowfin deduced from catch statistics and length composition taken by long-liners and surface fisheries operated in the Atlantic Ocean. After Honma and Hisada (unpublished)

ıııııı	general distribution range of the eastern systematic fraction
⊥⊥⊥⊥	general distribution range of the western systematic fraction
⟺	migratory routes of the eastern systematic fraction
⇠ ▬ ⇢	possible migratory routes of the eastern systematic fraction
⟷	migratory routes of the western systematic fraction
⇠ - ⇢	possible migratory routes of the western systematic fraction

SPINY LOBSTER FISHERY OF THE CARIBBEAN [1]

by

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1 INTRODUCTION

Spiny lobsters are in great demand, and they constitute one of the most valuable fishery resources of the Caribbean. They are produced in relatively small quantities in most countries of this region, and there is great interest in increasing catches.

2 SPECIES

The spiny lobster fishery of the Caribbean area is supported by a number of species of the family Palinuridae. Spiny lobsters are often called crawfish or sometimes crayfish. These latter names are also applied to fresh water crustaceans, and the preferred English common name is spiny lobster. In the French islands of the Caribbean the spiny lobster is called langouste and in Spanish territories langosta.

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[1] Contribution No. 1165 from the University of Miami, Rosenstiel School of Marine and Atmospheric Sciences, Miami, Florida

4.23

Spiny lobsters are characteristically animals of warm seas and they occur widely distributed in the middle latitudes over the world. Various species support commercial fisheries in Australia, South Africa, Japan and elsewhere. In the United States there is a fishery in California and one in Florida. Many countries in the Caribbean produce spiny lobsters and they are an important part of the marine resources of this area.

In the Caribbean Panulirus argus is by far the most important species caught. They are found in the western Atlantic from Rio de Janeiro, Brazil, to about Beaufort, North Carolina, and in Bermuda and the Bahamas. In addition to Panulirus argus other spiny lobsters are occasionally caught in small numbers. These include Panulirus guttatus, Paninustus truncatus, Justitia longimana, and Palinurellus gundlachi. A related animal, the Spanish or sand lobster, Scyllaridea aequinoctialis, is occasionally caught in traps set near sandy bottoms.

3 REPRODUCTION

3.1 Sexual dimorphism

During the breeding season the female is distinguished by the presence of the egg mass adhering to the underside of the abdomen. Before eggs are laid the female often carries a grey or grey-black substance attached to the undersurface between the last pair of walking legs. This is the sperm packet which has been attached by the male during copulation. The male may be distinguished by the tips of the fifth pair of walking legs, which end in single points; in the female these end in three points formed by spurs. The male has swollen sexual openings at the base of the last pair of walking legs; in the female these openings are smaller and are at the base of the third pair of legs.

3.2 Mating and egg deposition

Mating occurs in the spring, usually between February and April. During copulation the male exudes a viscuous fluid from the openings at the base of the last pair of walking legs. This becomes attached to the undersurface of the female between the last three pairs of legs and hardens to form the dark greyish sperm sac.

Shortly following the mating act the female lays her eggs. These are bright orange-red in colour and are about one millimetre in diameter. They are fertilized by sperms released from the sac as she scratches it with the tips of her legs. The eggs are attached to the underside of the tail by a cementing substance. The number of eggs is about 500 000 in a 9 in animal, increasing with the size of the female lobster.

Egg-laying is usually completed by the end of July although a few individuals spawn later than this; occasionally egg-bearing females are caught as late as November. The season of reproduction is extended both earlier and later in warmer parts of the Caribbean. Females commonly move into deeper water while the eggs are incubating. The eggs hatch within about three weeks after laying, at which time the females return to shallow water. In most cases lobsters reproduce first at a length of about 20 to 23 cm (8 or 9 in) but occasionally smaller animals, down to a length of about 15 cm (6 in), have been found carrying eggs.

3.3 Larval forms

The egg hatches into a small larva which undergoes a number of complicated changes before it reaches the more familiar lobster form. The larval stages of the spiny lobster occupy a considerable time, perhaps several weeks. During this period they drift or swim feebly and they may be carried considerable distances by ocean currents. Further details are given on the larval stages below, in the section on Artificial Culture.

4 GROWTH

Growth in the adult phase of the spiny lobster takes place following moulting of the hard exoskeleton. In warmer parts of the range moulting and growth may take place throughout the year. In the Bahamas and elsewhere most males and young females are found moulting in the months of April to June, and again during October to December. Mature females moult during the early spring and sometimes during August after they have shed their eggs.

During moulting the lobster ordinarily seeks shelter and is commonly found in traps. Moulting takes place when the old shell cracks along certain lines. It becomes dislodged first in the cephalothorax and then in the abdominal region. The new shell hardens in about one to two weeks. After losing the old shell the lobster increases in size by absorbing water.

Growth between moults is about 5 per cent of the body length in the case of large lobsters. A lobster 9 in long may grow about an inch and a quarter during the year.

5 FOOD AND ENEMIES

The spiny lobster has a wide range of food and is frequently a scavenger. Although it does not possess claws, it is provided with strong jaws which enable it to eat small shelled animals. Examination of the stomach shows small molluscs, such as young conchs, sea snails, clams and, occasionally, young lobsters. Seaweed is frequently found in the stomachs, but may not necessarily be of food value. Lobsters will also eat the fresh and dried meat of fish. Food is usually detected by the lobster at some distance by means of a special sense in the whips.

In the early stages of development, the spiny lobsters are small, transparent creatures which drift in the water. In these stages they are eaten by a great variety of fish and other animals. After they change into the adult form, but while they are quite small, they crawl among the rocks or grass and are eaten in large numbers by groupers and other bottom fish. The older lobsters, even up to a large size, are food for sharks, groupers and jewfish.

6 MIGRATIONS

Spiny lobster movements apparently are mostly random wanderings, usually over short distances in the order of five miles or less (Dawson and Idyll, 1951). At all times of the year small numbers of lobsters undergo local movements; these depend upon temperature, weather and food supply. Occasionally movements parallel to the shore have been recorded, mostly northward during the summer and southward during the winter.

More regular seasonal movements are associated with breeding habits. During February to April lobsters in some areas tend to collect inshore while mating. During April and June females move to deeper water where the eggs are laid; they return during July and August. Lobsters also tend to move offshore during the cold months of December and January.

A curious type of mass movement of lobsters has occasionally been observed. In Bimini, Bahamas, spiny lobsters were seen to migrate in a southwesterly direction, off the western shore of north Bimini (Herrnkind and Cummings, 1964). At a depth of 100 ft migrating lobsters were observed descending an abrupt slope on the edge of the Bahama Bank about a mile from the island. Over a hundred individuals could be seen at one time, moving over sandy areas in single file chains of three to thirty individuals, walking with the cephalothorax of one directly over the extended abdomen of another. Separate chains moved in parallel directions over an area of at least a mile along the shore and a mile out to the edge of the Bank.

In Florida long coastwise migrations have been observed (Dawson and Idyll, 1951). Six tagged lobsters moved 100 mi or more, the longest migration being 125 miles. In this same population, however, 78 per cent of the tagged lobsters travelled less than 6 mi from the place where they were released and 90 per cent travelled 20 mi or less.

7 COMMERCIAL EXPLOITATION

Although spiny lobsters are widely distributed in the Caribbean, in only six countries in the area, Bahamas, British Honduras, Cuba, Jamaica, Nicaragua, and Puerto Rico, can it be said that a sizeable fishery exists (Table I). Small to moderate landings are made in other areas, sometimes as a consequence of specialized fishery, but in some cases landings are incidental to other kinds of fishing.

4.23

TABLE I

Landings of Spiny Lobsters in Some Caribbean Countries - 1964-1967

(Weight of whole lobsters in 1 000's of pounds)

	1964	1965	1966	1967
Bahamas	1 750.0	2 220.7	1 720.5	2 000.0
British Honduras 1/	1 137.6	1 254.9	1 163.7	949.8
Cayman Islands 1/	1.5	1.8	2.4	1.0
Colombia	31.7	28.2	72.2	105.7
Cuba 2/	14 520.0	20 020.0	19 800.0	18 260.0
Dominica				1.0
Dominican Republic	167.4	161.9	202.7	138.2
Grenada	18.0	19.5	21.0	22.5
Guadaloupe 2/		46.3	44.1	55.1
Guatemala	112.8	50.9	75.4	66.6
Haiti	336.3	726.5	637.9	643.6
Honduras	106.5	933.4	543.5	63.5
Jamaica 2/				1 502.3
Martinique			18.0	36.0
Mexico 3/			370.3	
Nicaragua 1/	750.0	1 116.0	993.0	1 215.0
Panama				50.0
Puerto Rico	1 500.0	1 750.0	2 000.0	2 000.0
St. Kitts		94.0	100.0	
St. Lucia #	14.2	18.1	16.1	13.9
St. Vincent				38.0
Turks & Caicos 1/	267.3	249.6	287.7	366.6
Venezuela	263.2	247.4	277.3	242.2
Virgin Islands (U.K.)			17.7	15.8
Virgin Islands (U.S.A)				74.6°

1/ Data converted from tail weight to whole weight by multiplying by 3

2/ Date from U.S. Fish & Wildlife Service (from export data only)

3/ Data from U.S. Fish & Wildlife Service (Caribbean coast only)

# To September 1967

o Landings of 1967 and part of 1968

The general pattern is for the big producing countries to export most of the lobsters caught (Table II). The United States (including Puerto Rico) is the most important importer of Caribbean spiny lobsters. The United States does not permit the importation of lobsters from Cuba; Canada and France are the main export markets for Cuba (Windley, 1968).

Spiny lobsters are usually exported as frozen tails. Some come live to the United States from the Bahamas.

TABLE II

Proportion of Spiny Lobsters Exported, Countries Receiving Exports and Forms Exported

	% exported	Countries receiving exported lobsters	Forms exported
Bahamas	85	USA	Frozen tails; alive
British Honduras	90	USA	Frozen tails
Cayman Islands	0		
Colombia	0		
Dominica	0		
Dominican Republic	60	Puerto Rico	Frozen tails; alive
Grenada	0		
Guatemala	19	USA, Puerto Rico	Frozen tails
Jamaica	< 10	USA	Frozen tails
Martinique	25	France, Puerto Rico, USA	Live
Mexico	NA		
Nicaragua	95	USA	Frozen tails
Panama	80	USA	Frozen tails
Puerto Rico	0		
St. Kitts	>90	Puerto Rico, Neth. Antilles, U.S. Virgin Islands	Live
St. Lucia	80	Trinidad, Barbados, U.K., Puerto Rico, USA	
St. Vincent	0		
Turks & Caicos	100	USA	
Venezuela	3	Curacao	
Virgin Islands (U.K.)	77	USA, Virgin Is.	
Virgin Islands (U.S.A)	0		

NA = not available

8 POTENTIAL FOR INCREASED CATCHES

The prospects for significantly increased catches of spiny lobsters in the Caribbean do not appear to be bright. In most countries where catches are small it is because stocks are small. Additional research and exploratory fishing is required in many areas to be certain of this.

There are some Caribbean areas where additional production may be possible. These include the waters of Panama (Butler and Pease, 1965), Colombia, and Venezuela.

9 FISHING METHODS

Spiny lobsters are caught with traps, baited and unbaited, by hoop nets, pull nets, spears or grains, bully nets, grabs, rafts, ice cans and gasoline drums. The following descriptions of the gears are adapted from Smith, 1959 (see also, Cope and Knake, 1959).

4.23

9.1 Wooden trap

Wooden traps are the gear most commonly used in Florida. They are approximately 3 x 2 x 2 ft in size, constructed of wooden lath spaced 1/2 in apart, with an opening in the top guarded by wooden teeth. These traps are buoyed, weighted and baited with fish heads, or other similar material, wired to the inside.

9.2 Wire trap

These are made by the fishermen of galvanized chicken wire with meshes 1/2 in^2. The average dimensions are 1/2 x 3 x 2 feet. The conical entrance passage is on one side, about 2 in from the bottom, and curves upward slightly at the inside end. It is about 8 in in diameter at the entrance, with a 4 in opening at the inside. These traps are only used in comparatively deep water and are weighted, buoyed and baited in a manner similar to wooden traps. They do not appear to differ appreciably in efficiency from the latter, but have the advantage of catching scale fish in the same operation.

9.3 Hoop nets or pull nets

The hoop net consists of a circular piece of fish net supported by an iron hoop up to 6 ft in diameter, in such a way that the net sags in the center. Bait is tied to the center of the net, which is then lowered to the sea bottom by means of a rope line and bridle attached to the hoop. After a varying number of hours on the bottom, the hoop is hauled at a fast, steady pace so that crawfish attracted to the bait will be held in the sagging center of the net.

9.4 Grains, spears and grabs

These methods are fairly common in the Caribbean, where the lobster is caught for immediate use of the fisherman, and are the principle commercial methods in British Honduras. Lobsters pierced by spears or by two-pronged grains are damaged and are difficult to keep alive in live cars or fish wells. Since the bully is equally effective in catching spiny lobsters and does not harm them, it is greatly preferred.

When spiny lobsters are molested they are said to leave the neighbourhood. Since they are somewhat gregarious, there is a possibility that the escape of lobsters which have been speared may cause a general exodus from the immediate locality. Fishermen attribute this to a reaction to the blood or flesh of damaged individuals. This is probably not so, since they are cannibalistic. Lobster heads may even be used to bait traps.

Grabs are long paired poles, hinged near the bottom so as to act as tongs. They are not used very frequently and offer no advantage over the bully.

9.5 Torching

Advantage is sometimes taken of the nocturnal and frequently gregarious behaviour of the spiny lobster by fishing at night with gasoline lanterns, torches or flares. In shallow water the lobsters are often caught by hand, although spears and nets are also used.

9.6 Bully nets

The bully net is a small hoop net about 18 in in diameter and 2 ft in depth with 1/4 in mesh. The hoop is fastened at right angles to a long pole.

The bully net is used from a small boat. During the daytime the fisherman detects the lobsters by means of the whips or antennae, which project from beneath rocky ledges, holes, or marine growth, usually using a glass-bottomed bucket to improve his vision. A second pole carrying a stiff wire probe is used to force the lobster from hiding, and the hoop is then placed over the lobster in such a way that the net streams upward. As the hoop surrounds the lobster it jumps backward into the net, and, by a sideway and upward movement, the fisherman traps it.

9.7 Ice can and gasoline drum traps

Ice can traps are made of discarded metal ice molds used in ice manufacturing plants, and consist of light steel rectangular tanks about 4 ft deep and 9 in by 30 in in section. The trap is prepared by crushing in the rim of the opening to leave two openings of sufficient size to admit the spiny lobster. Small holes are punched in the sides in order to allow ready egress of water.

Prior to use the trap is allowed to remain under water for several weeks, during which time a growth of marine organisms accumulates. Spiny lobsters are believed to avoid traps which have not been acclimated in this manner.

The can trap does not need bait, since the lobsters enter it in the daytime in much the same way as they enter rocky crevices in search of shelter.

In most regions of the Caribbean, traps are the principal gear, although a significant quantity of lobsters are caught by diving and with spears (Table III). In the large fisheries of Jamaica and Puerto Rico, the biggest catches are made with wire traps. Wooden or cane traps catch about a third of the production in British Honduras, a quarter of the production in the Dominican Republic and smaller quantities in various other areas. In British Honduras about two-thirds of the production is by diving, and this proportion has increased in recent years. In Colombia it is recorded that the whole catch is made by divers, and in Grenada, Netherlands Antilles, Panama, St. Vincent, Turks and Caicos Islands and the British Virgin Islands, all or a substantial proportion of the catch is made in this way. Other methods of fishing are inconsequential in the Caribbean area.

TABLE III

Percentage of Catch by Various Gears

	Spear	Diving	Wood	Wire	Bully nets	Snares	Stamping	Bait
Bahamas		x			75			No
British Honduras		66	33					No
Cayman Islands	75						25	No
Colombia		100						No
Dominica		x		x		x		Yes
Dominican Republic	x	x	25	75				No
Grenada	25	75						No
Jamaica	x			100				Y/N
Martinique	x	x	x	75	x			Yes
Netherlands Antilles		100		x				No
Nicaragua		x		x				Yes
Panama		100						No
Puerto Rico	x	x	x	75				No
St. Lucia	x	x		50			Pots 50	Yes
St. Vincent	25	50		x				No
Turks & Caicos		100		x				Yes
Venezuela	x	x		100				Yes
British Virgin Is.		50	x	25				Yes
U.S. Virgin Is.		x	75	25				Yes

x = Some fishing by those methods

10 REGULATIONS

A summary of the regulations applied to lobster fishing in various parts of the Caribbean area are presented in Table IV. It will be noted that there is considerable variability in respect to whether fishermen are licensed, whether boats are licensed, whether the amount of catch is reported and in some other regulations. On the other hand there is some consistency in the imposition of a closed season, minimum size and protection of egg-bearing females.

4.23

TABLE IV

Regulations

A

	Licensed fishermen	Licensed boats	Reporting catch	Closed season	Closed area	Min. size limit	Max. size limit	Min. weight
Bahamas	No	No	Yes	1 Apr.–31 July	Yes	3 3/8 in Carapace	No	1 lb Tails 5 oz
British Honduras	No 1/	No 1/	No 1/	15 Mar.–14 July	No	3 1/2 in Carapace	No	7 oz tails
Cayman Islands	Yes	No		1 Feb.–31 July		9 in total		
Colombia	No	No	No	Feb.–June		25 cm	No	No
Dominica	No	Yes	No	No				
Dominican Republic	Yes	Yes	Yes	Yes	Yes	16 cm	No	No
Grenada				1 May–30 Sept.		9 in total		
Guatemala	(No regulations; no special fishery)							
Jamaica	(No regulations; mostly incidental fishery)							
Martinique						15 cm	(Mostly incidental fishing)	
Netherlands Antilles						25 cm	(Mostly incidental fishing)	
Nicaragua	Yes	Yes	Yes	No	No	8 in total	No	
Panama	(No regulations)							
Puerto Rico	Yes	Yes	Yes					
St. Kitts-Nevis-Anguilla	No	No	No	No	No	9 in total	No	1 lb
St. Lucia		Yes				9 in		1 lb
St. Vincent				1 May–31 July				
Turks & Caicos	Yes	Yes	Yes	1 Apr.–31 July	Yes	4 in Carapace		
Trinidad	(No regulations; no special fishery)							
Venezuela	Yes	Yes	Yes	May–Aug.		Carapace 8 cm		

1/ Regulations pending

TABLE IV

Regulations

B

	Gear restrictions	Licensing of processors	Licensing of exporters	Protection of ripe lobsters	Protection of soft-shelled lobsters
Bahamas	No traps, no underwater weapons	Yes	Yes	Yes	Yes
British Honduras	No	Yes	Yes	Yes	Yes
Cayman Islands					
Colombia	No	No	No	No	No
Dominica					
Dominican Republic	Yes			Yes	
Grenada				Yes	
Guatemala	(No regulations; no special fishery)				
Jamaica	(No regulations; mostly incidental fishery)1/				
Martinique	(Mostly incidental fishing)				Yes
Netherlands Antilles	(Mostly incidental fishing)				
Nicaragua				Yes	
Panama	(No regulations)				
Puerto Rico				Yes	
St. Kitts-Nevis-Anguilla	No			Yes	No
St. Lucia				Yes	Yes
St. Vincent				Yes	
Turks & Caicos	No guns, spears			Yes	
Trinidad	(No regulations; no special fishery)				
Venezuela				Yes	

1/ Regulations pending

4.23

Some of the regulations deserve special discussion. It is not always recognized that fishery regulations are of two general types. One type is designed to protect the population from over-exploitation. "Biological regulations" designed to prevent over-fishing include protection of reproducing animals and prohibition against the capture of undersized lobsters. The other type of regulation is economic, meaning that it prevents waste of the resource by catching animals which are not desired on the market by imposing size regulation and by prohibiting the capture of soft-shelled animals. Both these kinds of regulations are necessary and desirable but in many cases they are confused.

Biological regulations should be imposed for the purpose of permitting the maximum sustained catch, that is to say the maximum weight of lobsters each year without reducing the stock's capability of maintaining itself. It is a widespread but mistaken view that the main method of ensuring this is to protect reproducing animals. This is the rational for protection of egg-bearing females and for the imposition of minimum and maximum size limits. The supposition is that the size of the exploitable population is determined by the number of eggs laid. But this is incorrect for the majority of marine animals, including both fishes and invertebrates like the lobster, over a wide range of population sizes.

The level of necessity to protect mature animals, especially females, is closely related to the number of young produced. For some whales, where only one calf is produced every two years or less, the loss of mature females has a rapid and profound effect on the numbers of young produced. Most sharks produce 10 or fewer young a year, and the population can quickly be seriously reduced because recruitment is insufficient. Marine turtles produce only a few hundred eggs, and exploitation of egg-laying females has destroyed some stocks.

But for most marine fishes the number of eggs produced is so large that even very heavy removal of mature females still leaves enough spawners to provide sufficient young to maintain a high level of population. Of course, variations take place in the size of fishable stocks, but in the cases studied these variations have been shown to be a result of favourable or unfavourable environmental conditions in the sea (temperature, currents, food supply).

In some cases big populations have resulted from small spawning stocks and small populations from highly successful spawning.

Studies have not been made for spiny lobsters to test whether the number of eggs produced affects the numbers of adults produced in the next generation, but because of the very large number of eggs produced by individuals (a half million or more) it seems likely that a shortage of eggs is not likely to occur in the levels of population present in most cases. Of course, there is a level below which the number of spawns cannot be taken without reducing the number of young to the danger point - in the extreme case, if no mature females are left, no young will be produced. But before this critical point is reached in most marine fisheries - probably including spiny lobster fisheries - profits fall so far the fishing stops.

Despite the likelihood that fishing does not reduce the number of young of spiny lobsters below the danger point, overfishing and depletion of lobster populations can take place. It is important to realize that overfishing does not always - in fact, does not usually - involve reducing the number of reproducing individuals. Instead, if fishing is so intense that lobsters are reduced in average size and are allowed to be caught so small that less total catch is obtained from the stock than is possible if a larger size at capture is maintained, then depletion results. Overfishing, then, is a rate of capture, and a capture of undersized individuals, which results in less total production than is possible with a more rational fishing pattern.

If this is true, then the protection of egg-bearing females does not protect the stock, although it may be necessary if the quality of flesh is poor at this time. In the same way, a closed season during the period when lobsters are spawning should not be imposed for the sake of protecting the spawning animals, nor should minimum size limit be imposed only for the sake of ensuring that lobsters spawn at least once.

This is not to say that some or all of these regulations may not be desirable, but they should be imposed from different points of view in protecting the spawning stock, namely to attain the maximum sustainable yields.

10.1 Licensing fishermen and boats

Officials of about half the countries which responded to a questionnaire said that they licensed either fishermen or boats or both. This is a useful regulation since it allows reliable estimates to be made of fishing effort. Even if no revenue is derived from these licenses they are useful from the data they yield on fishing effort, and countries should be encouraged to require licenses.

10.2 Reporting catch

Most countries reporting said that they require statistics of catch to be reported. This is a highly desirable regulation and should be imposed by each country. Without reliable statistics of production it is impossible to evaluate the status of the fishery and therefore to judge whether over-exploitation is taking place.

10.3 Closed seasons

Nearly every country has a closed season. This ordinarily is in the spring and summer, corresponding to the spawning season. It was pointed out earlier that this is probably not justified from the biological point of view. On the other hand, if it can be shown that the lobster fishery in any region is over-exploited, a closed season is a device to cut down fishing effort. Also, the quality of lobsters is sometimes not as good in the summer as it is in other seasons, and, if this reduces the market value of the animals caught, it is desirable to prevent their capture.

10.4 Minimum size limits

Nearly all countries have minimum size limits, which ordinarily approximate 9 in total length (3½ in carapace length) or 1 lb in round weight. The announced reason for these regulations is ordinarily that this is about the minimum size that lobsters are observed to carry eggs. It was pointed out above that this is a false reason for establishing minimum size limits. It happens, however, that this is also the approximate size at which lobsters are acceptable in the market, and this is a valid reason for establishing a minimum size limit. Lobsters are captured at a size so small that their value is reduced and full economic uses are not made of the resource.

There is an additional important reason for establishing a minimum size limit, and this is to achieve the maximum sustained yield. This is the theoretical size of individual lobsters at which capture provides maximum production from the population. This size is determined by balancing the growth of individuals with the disappearance rate from death and predation. If lobsters are captured too small, production is reduced by not allowing them to increase to their optimum size. On the other hand, if the size limit is placed too high, it may be that some production is lost through disappearance by natural causes before the fisherman can make his harvest. Determination of this optimum size is difficult and has not been achieved for any spiny lobster population in the Caribbean.

This being the case, it is necessary to fall back on economic criteria for determination of the proper minimum size for spiny lobster, which is a perfectly acceptable method in the absence of other data.

10.5 Maximum size limits

There is no justification for imposing maximum size limits, since the number of eggs is not the determining factor in the size of the subsequent generation. Large lobsters which are caught should be retained since these are more likely to die than smaller individuals and thus to be lost as food.

10.6 Gear restrictions

Several countries restrict the kind of gear which may legally be used to catch spiny lobsters. Most of the regulations refer to prohibitions against using certain kinds of traps, or against spears and other underwater weapons. In some areas wire traps have been prohibited because if the traps are lost and cannot be recovered by the fishermen they may continue to kill lobsters caught in them. Ice cans are prohibited in some areas since they are likely to catch undersized lobsters. If enforcement of minimum size limits is effective so that all undersized lobsters are discarded, this gear would not be harmful.

In some areas, for example British Honduras, principal kinds of fishing gear are spears or underwater guns. In other areas these gears are illegal. The prohibition is probably wise. Lobsters struck with spear are likely to be killed or damaged and therefore to be of less value on the market. Furthermore, if undersized lobsters are shot they probably will die even if released; thus this kind of gear is wasteful of the resource.

4.23

10.7 Protection of soft lobsters

Several countries prohibit the capture or sale of soft-shelled lobsters. This condition prevails after the lobster has molted the old shell and before the new shell hardens. At this time lobsters are more likely to be injured, and it would probably be desirable not to capture any of them. On the other hand it is sometimes impossible to avoid capturing them, and apart from the increased possibility of injury, there is no good biological reason why they should not be captured and sold if the market will accept them. But they are not ordinarily desired by the commercial market, and if they cannot be sold they should not be brought to market.

10.8 Quota or maximum catch

British Honduras is apparently the only country in the Caribbean using the quota system to limit the total catch of lobsters. This is a device attempting to insure that over-exploitation of the resource does not take place. It is a desirable regulation providing the maximum sustainable yield has been determined. In the case of British Honduras this has been approximated, although no fully satisfactory investigations have been made to determine whether the quota as it exists is in actuality the proper one (Idyll, 1961). The quota has been raised successively over several years, from 400 000 lb beginning in 1948 to just over 1 million lb beginning in the 1964-1965 season (Allsopp, 1968). The population appears to be maintaining itself.

This kind of regulation is one of the most useful and effective if enough biological information exists on which to base a valid figure. It would be desirable to conduct population dynamics studies of the various larger lobster populations to lead to the determination of maximum allowable catches.

11 ARTIFICIAL CULTURE

In the last few years there has been a surge of interest in the possibility of artificial culture of marine organisms. Encouraging progress has been made in the culture of oysters and other molluscs, of shrimp and of some fishes. Great interest has been shown in the possibility of artificial culture of spiny lobsters. The prospects here are not promising. Spiny lobster eggs have been hatched and the larvae carried through several stages in the laboratory, but no successful experiments have been reported in which the larvae have been carried to metamorphosis. This being true even in laboratory conditions, the establishment of spiny lobster "farms" is a long way in the future. While it is not impossible that with further research artificial culture of lobsters can become successful, there are many years of research ahead before it becomes a reality.

There are two possible approaches to the "farming" of spiny lobster. One is to solve the problem associated with hatching the eggs and raising the animals through their various larval stages to saleable size. The other is to capture spiny lobsters which have been hatched and have grown to juvenile size in nature, then to capture, enclose, protect and feed them until they reach a size when they can be sold.

The greatest difficulties associated with the problem of raising spiny lobsters in hatcheries are the complexity and the long length of the larval life of these animals and the problems of finding suitable food for the various stages. All crustaceans pass through a number of larval stages, and in the case of Panulirus the larvae are unusually delicate.

Spiny lobster larvae are called phyllosomas. They are characterized by extreme flatness and by a long, divided appendage. These leaf-like larvae float in the water horizontally with their legs dangling. In captivity they are likely to become entangled with each other and with floating material in the water, and they are very easily killed. Because the larvae are pelagic, floating or swimming in mid-water, it is difficult to create artificial conditions that approximate those natural to the young animal. Although the evidence is not conclusive, it appears that larval and postlarval histories of spiny lobsters are long, perhaps several months (Sheard, 1949; Lewis, 1951), so that the expense of maintaining the animals until they achieve a reasonable size will probably be great. The very few experiments which have been carried on in hatching and raising spiny lobster larvae suggest that the difficulties of providing suitable food are great; the latter may be the principal problem faced.

Progress was made in the raising of spiny lobster larvae in 1958 when Japanese investigators found that they could feed them the larvae of brine shrimp, Artemia. In the next few years other Japanese investigators were able to raise larvae of the Japanese spiny lobster, Panulirus japonicus, to the seventh stage. This took 40 to 48 days, and it required 90 days to raise another series of the same species to the tenth larval stage. In 1966, 16 molts had been passed through and 178 days without metamorphosis. Of course, artificial conditions in the laboratory may not have been as satisfactory and it is possible that in nature metamorphosis is reached in a shorter period of time, and with fewer transformations than was the case here.

At the Institute of Marine Sciences, Phillip Robertson succeeded in hatching the larvae of the Florida and Caribbean spiny lobster, Panulirus argus (Robertson, 1968). These passed through 8 or 9 molts in 9 to 10 weeks, but they were still well short of metamorphosis when they died. Again, conditions in the laboratory may have been poorer than in nature, and these times may not be normal in the sea. Robertson was able to carry a related species, Scyllarus (one of the sand lobsters) all the way from egg through metamorphosis to the juvenile animals. There were seven larval stages, and at 20°C the total time was 32 to 40 days from hatching. The larvae all died three days after metamorphosis.

It is believed that Scyllarus has a shorter larval life than Panulirus. The evidence available - which is admittedly incomplete - suggests that the latter may be as long as six months.

So far no one has succeeded in raising Panulirus from the egg through metamorphosis.

A major problem is to find suitable food for advanced larval stages (Provenzano, in press). While Artemia larvae are satisfactory in the early stages, they seem not to satisfy the later stages of the spiny lobster, and this may be the reason for lack of success in carrying them beyond about the fourth stage. Temperature is another variable of importance.

Once the larval stages have been completed and the animal has achieved the juvenile form and lives on the bottom, the major part of the mortality has been passed. It may be feasible to collect small lobsters from the wild, protect and feed them, and raise them at a profit. This would involve some change in the conservation laws of most countries, to permit capture of undersized animals and to enclose these in ponds or tanks. Protection from predators and the provision of suitable food might promote rapid enough growth to allow farming of spiny lobsters. Animals at this stage eat scrap fish and other kinds of animal protein.

It is not known how long lobsters take to grow from the postlarval stages to a size suitable for marketing, but it is estimated that this is two years or more. It is possible that the amount of labour and food necessary would prevent this being a profitable operation. But there are reports that Japanese workers in southern Kyushu have achieved encouraging results. They catch small spiny lobsters in cages suspended in mid-water in vertical oyster culture or from tree branches put in shallow waters. The small lobsters, about 15 cm length, are put into ponds or shallow bays and are fed trash fish. Early experiments suggest that it may be feasible to produce saleable lobsters at a profit.

Quite clearly a great deal more information is required before any confident opinion can be given as to the feasibility of culturing lobsters with either of the two methods.

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APPENDIX I

NUMBER OF VESSELS AND FISHERMEN

	No. of smacks or boats	Av.No. men	Av. length in ft	No. of dinghies or canoes	Av.No. men	Av. length in ft	Proportion motorized	No. of fishermen full-time	Seasonal or part-time	Remarks
Bahamas	150	6	30–40	700	2	11	50	700	1 000	
British Honduras	132	3	16–35	102	1	12–16	95	403		
Cayman Islands				8	2	16	100		16	
Colombia				ca 150	6	7–8	0		800–1 000	
Dominica				ca 600	2–3	12–22	80	1 000	500	No special fishery
Dominican Republic				2 000	2	12–25	10	1 500	2 250	
Grenada				7	4	12–28			28	
Guatemala			(No special fishery for lobsters)							No special fishery
Jamaica	NA[1]	3	14–30							
Martinique				1 200	–	20	60	1 800		No special fishery
Netherlands Antilles			(No special fishery for lobsters)							No special fishery
Nicaragua	47–61	3–4	14–64				100	168		
Panama	NA									No special fishery
Puerto Rico	1 300	2	16–40				75	1 400	1 400	
St. Kitts-Nevis-Anguilla				15	4	18–25	100	40	20	
St. Lucia				694	3	23–28	50	2 400	800	
St. Vincent				10	–	14–20		40	30	No special fishery
Trinidad										No special fishery
Turks & Caicos Island	27		14–35				80	70		
Venezuela				300	3–4	26	100	800–900		
British Virgin Islands				12	2	15–21	100	3	22	
U.S. Virgin Islands				6–10	2	12–40	100			

[1] NA: not available

4.23

APPENDIX II

REPORTED SEASONS OF MATURITY, SPAWNING, MOLTING AND MIGRATION OF CARIBBEAN SPINY LOBSTERS

	Dates ripe	Dates spawning	Location of spawning	Dates molting	Dates of migration
Bahamas	Apr.-June	May-July	Offshore	Apr.-June	all
British Honduras		Feb.-July	On shore	all year	Nov.-Jan.
Cayman Islands	May-July	May-July	Offshore	May-June	
Colombia	Oct.-Feb.		On shore		
Dominica	Aug.-?	August		July-Aug.	
Dominican Republic	Mar.-Sept.	Aug.-Sept.	On shore		
Grenada	Apr.-June	July-Sept.	Offshore	Early spring	
Jamaica	Mar.-Apr.	Dec.-Jan			Mar.-Apr.
Martinique	June-Aug.	Aug.-Sept.	On shore		
Nicaragua	Nov.-Jan. Mar.-May	Feb.-Apr. June-July			
Puerto Rico	Jan.-Feb.	Mar.-Apr.		May-June	Oct.-Apr.
St. Vincent	May	May-July	On shore	Mar.-Apr.	Feb.-Apr.
Turks & Caicos	Feb.-Nov.	Feb.-Nov.		Feb.-Nov.	Nov.-Dec.
Venezuela	July-Nov.	Sept.-Apr.		May-Dec.	August
British Virgin Islands	May-July	May-July		Oct.-Feb.	Sept.-Oct. Feb.-Mar.

SHRIMP RESOURCES OF THE CARIBBEAN SEA AND ADJACENT REGIONS[1]

by

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1 INTRODUCTION

Because assessments of renewable resources such as shrimp present several difficulties, it may be well to begin by specifying the precepts followed in this paper.

The area considered extends from North Carolina, U.S.A., through the Gulf of Mexico and the Caribbean Sea - specifically, the western Atlantic between Cape Hatteras, North Carolina, and the delta of the Orinoco River, Venezuela (here termed the Carolina-Venezuela region).

Shrimp catches and landings, unless otherwise noted, are reported in live weight of shrimp (heads on), in metric tons. In all countries except the United States and Mexico, landings reported as headless shrimp were multiplied by a factor of 1.68 to convert to live weight. Conversion factors used for Mexican landings were given by Lindner (1957), and those for U.S. landings appear in various statistical publications of the Bureau of Commercial Fisheries, Fish and Wildlife Service.

Where the fisheries appear to be stabilized, averages of the landings over a period of years were used so that undue emphasis was not given to unusual conditions; elsewhere, the latest data available were used. For some countries, particularly Colombia, production data are not recent.

Catches made by U.S. vessels off Mexico, Honduras, and Nicaragua were included in the landings of those countries to improve estimates of the shrimp stocks in those areas.

No projections were made for increased production from shrimp mariculture. Although shrimp culture has great future promise (Lindner and Cook, 1968), it is still in the experimental stage, and its feasibility for the region has not been proven.

Because no reliable data are available on the species composition of landings (except in the U.S.A. I grouped all species by country. These data on current landings and estimates of maximum yields are presented in Table I.

Only the species that normally spawn in waters of relatively high salinity are considered. Shrimp which are not now of some commercial importance or which are not likely to become of commercial importance in the foreseeable future are not included. Neither are the species of small size included (such as those of the genera Parapenaeus, Penaeopsis, and Trachypeneus) that may be taken and utilized incidentally in present commercial operations.

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[1] Contribution No. 284 from the Bureau of Commercial Fisheries Biological Laboratory, Galveston, Texas 77550

TABLE I

Estimated current and potential production (metric tons, heads on) of shrimp from Cape Hatteras, North Carolina, U.S.A., to the Orinoco Delta, Venezuela

Country or area	Current production	Potential production
U.S.A.	78 700[1]	102 000–127 000[2]
Mexico	30 900[3]	33 000
British Honduras	200[4]	400
Guatemala	[5]	200[6]
Honduras	2 100[7]	3 000
Nicaragua	2 100[8]	4 000
Costa Rica	[5]	[9]
Panama	[5]	[9]
Colombia	400[10]	2 000
Venezuela	7 800[11]	11 000
Bahama Islands, Greater and Lesser Antilles, except Cuba	1 000[12]	2 000
Cuba	2 000[13]	2 500[13]
Total	125 200	160 100–185 100

[1] Based on 10-yr average, 1958-67

[2] Estimates include production gains of 15 000 to 40 000 t from future management programmes. This is the only country for which such estimates have been included.

[3] Based on 9-yr average, 1958–66. Includes landings of U.S. vessels whose catches were made off the coast of Mexico. Species caught by these vessels are *Penaeus d. duorarum*, *P. a. aztecus*, *P. brasiliensis*, and *P. setiferus*. Cuban landings from off Mexico are not available.

[4] Based on preliminary records of 1967 exports of 173 tons.

[5] Insignificant.

[6] Based on 140 t landed in 1959 (Croker, 1967).

[7] Estimate based on U.S. import records and landings of U.S. vessels whose catches were reported as made off Honduras in 1965.

[8] Based on local landings (Robert Ellis, personal communication) and landings by U.S. vessels whose catches were reported as made off Nicaragua in 1966.

[9] Insignificant. Based on recent exploratory fishing surveys (Robert Ellis, personal communication).

[10] Estimate by Lindner (1957).

[11] From 6-yr records of landings in 1962-67. A sizeable quantity of Venezuelan landings is heads on, but because no reliable estimates are available, all landings were considered heads off.

[12] All of the countries and entities throughout the Bahama Islands and the Greater and Lesser Antilles, except Cuba, were grouped. Although practically all have localized shrimp fisheries, they are not large nor are they likely to become so. Because available landing data are scanty, estimated and potential production are approximations only.

[13] Personal communication (J.R. Gonzales Cardulis).

2 SPECIES AND RANGES OF COMMERCIALLY IMPORTANT SHRIMP IN THE CAROLINA-VENEZUELA REGION

Estimates of maximum production were restricted to the 10 species and subspecies whose ranges and known concentration localities follow.

2.1 Shallow-water forms of the genus Penaeus.[2]

2.1.1 Penaeus setiferus (Linnaeus) - the white shrimp - has been reported from Fire Island, New York, to about Punta Chapote, Campeche, Mexico (Lindner and Cook, 1970). Three distinct locations where this species is fished intensively are: (a) from Cape Hatteras, North Carolina, to Fort Pierce, Florida, with the centre of abundance off Georgia and northeastern Florida; (b) from Apalachicola Bay, Florida, to northeastern Mexico, with the centre of abundance in Louisiana; and (c) from about Tupilco, Tabasco, Mexico, to Campeche, Mexico, with the centre of abundance near Isla del Carmen, Campeche, Mexico.

2.1.2 P. schmitti Burkenroad - the camarón blanco - extends throughout the Antilles and from Belize, British Honduras, to Laguna, Brazil (Pérez Farfante, 1970). Concentrations are scattered more widely than those of P. setiferus. P. schmitti occurs in fishable concentrations throughout the region in Cuba, Guatemala, Honduras, Nicaragua, Colombia, Venezuela, and Trinidad (Lindner, 1957; U.S. Fish and Wildlife Service, 1958; Pérez Farfante, 1970). These stocks do not seem to be especially large except in Cuba, Honduras, Nicaragua and Venezuela. In none of these localities, however, do stocks appear to be comparable in numbers to the stock of P. setiferus off Louisiana.

2.1.3 P. aztecus aztecus Ives - the brown shrimp - ranges from Martha's Vineyard, Massachusetts, south through the Gulf of Mexico to about Campeche, Campeche, Mexico (Pérez Farfante, 1969). There are four principal concentrations: (a) along the Carolinas; (b) between the State of Mississippi and northeastern Mexico; (c) from north of Tampico to Veracruz, Mexico; and (d) along the coast of Tabasco and southwestern Campeche, Mexico. The area of greatest abundance is in the north central and northwestern Gulf of Mexico, namely, concentration (b) above (Cook and Lindner, 1970).

2.1.4 P. aztecus subtilis Pérez Farfante - the camarón marron - occurs throughout the Antilles and from Honduras to Cabo Frio, Brazil. It is not of great commercial importance in the Antilles and does not rank high in the commercial catches of Honduras and Nicaragua. It is, however, of some importance in Venezuela. Major stocks appear to be south of the region being considered here, along the coasts of Guyana, Surinam, French Guiana, and Brazil (Pérez Farfante, 1969).

2.1.5 P. duorarum duorarum Burkenroad - the pink shrimp - ranges from lower Chesapeake Bay, south through the Gulf of Mexico to Isla Mujeres, Quintana Roo, Mexico (Pérez Farfante, 1969). The two greatest concentrations are along the southwest coast of Florida and on the Campeche Banks off the state of Campeche, Mexico.

2.1.6 P. d. notialis Pérez Farfante - the candied or caramel shrimp - is known from Cuba to the Virgin Islands and from Bahía de la Ascensión, Quintana Roo, Mexico, to Cabo Frio, Brazil. It also ranges from Cabo Blanco to Angola in the eastern Atlantic. It is concentrated in Cuba, British Honduras, Honduras, Nicaragua, and the Gulf of Venezuela (Pérez Farfante, 1969).

2.1.7 P. brasiliensis Latreille - the spotted shrimp - ranges from Cape Hatteras to the Tortugas Islands; from the Bermuda Islands throughout the Antilles; and from Cabo Catoche, Mexico, to Lagoa dos Patos, Brazil (Pérez Farfante, 1969). Small quantities are taken for bait in Biscayne Bay, Florida, but the species is not of great commercial importance in the region except from Cabo Catoche to Isla Mujeres, Mexico, the eastern coast of Honduras, the coast of Nicaragua, and to some extent in Colombia and Venezuela. The largest stocks apparently are south of the region considered here.

2.2 Shallow-water forms of the genera Xiphopeneus and Sicyonia

2.2.1 Xiphopeneus kroyeri (Heller) - the seabob - ranges from Cape Hatteras, North Carolina, to southern Brazil (Williams, 1965). Commercial concentrations are in the northern Gulf of Mexico (particularly west of the mouth of the Mississippi River), Nicaragua, eastern Venezuela, and Trinidad. The largest stocks are south of the region considered here.

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[2] Species of this genus produce practically all of the commercial catch in the region under consideration. I have followed Pérez Farfante (1967, 1969 and 1970) for the taxonomy and ranges of shrimp of the genus Penaeus, and am indebted to her for permitting me to use her material on the distribution of Penaeus of the western Atlantic.

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2.2.2 Sicyonia brevirostris Stimpson - the rock shrimp - ranges from Norfolk, Virginia, through the Gulf of Mexico to Yucatan, Mexico, and throughout the Bahama Islands and Cuba (Williams, 1965). Known concentrations occur: (a) from about Charleston, South Carolina, to New Smyrna, Florida (Anderson, 1956); (b) in the northwestern Gulf of Mexico (Brusher and Renfro, MS); and (c) in the Gulf of Campeche (Hildebrand, 1954).

2.3 The deep-water form of the genus Hymenopenaeus[3]

2.3.1 Hymenopenaeus robustus Smith - the royal red shrimp - ranges throughout the entire region (Thompson, 1967 and Roe, 1969, cited numerous references on the exploratory work of S. Springer, H.R. Bullis, and others which show the distribution of this species). Fishable concentrations are known to exist only in three locations, all of which are along the coast of the U.S.A: (a) off the east coast of Florida between latitudes 27°31' and 31°00'N; (b) along the Florida Straits between longitudes 82°20' and 84°00'W; and (c) southeast of the Mississippi River Delta between longitudes 87°15' and 91°00'W. These grounds are named, respectively, St. Augustine, Dry Tortugas, and Mississippi Delta (Roe, 1969).

3 PROBLEMS IN ESTIMATING POTENTIAL HARVEST

At this point it may be fruitful to discuss the methods for estimating potential harvest for regions about which we have only limited information. Bear in mind though that what we are striving for is a reliable estimate of the fishable magnitude of a stock of shrimp. We need to know how best to estimate the maximum sustained number of tons that can be harvested each year from a stock. The most precise measures of production are those based on growth, mortality, and recruitment rates from heavily fished stocks. These rates, however, are difficult to determine and, indeed, may be impossible to obtain even though the species is heavily fished. It is clear, therefore, that in most fisheries we are obliged to use as the best estimate some amount that is less accurate than might be desired. The degree of accuracy, of course, depends on the method used in making the estimate.

For a region that has not been fished, we might base estimates (more aptly, guesses) on the range of species or on the size of the trawlable fishing grounds. Projections of the fishable magnitude of stocks of shrimp on these bases are subject to such wide error, however, that they are of little use because shrimp do not distribute themselves uniformly over vast areas. Instead, they concentrate in certain localized areas where, presumably, temperature, substrata, and food are suitable. For most species, only fragmented bits of information are available on these subjects.

The situation would be considerably improved if, in addition to species range and trawlable area, we also had information from exploratory fishing. We would still, however, not be able to make reliable estimates of potential harvests. Estimates calculated from exploratory fishing alone approximate only the standing crop or, in other words, only the weight present at one time. An estimate of the standing crop may be highly deceiving if it is used to estimate the fishable magnitude of a stock.

An additional difficulty in establishing potential harvests from catches of exploratory vessels was pointed out by Stark and Slack-Smith (1968). They demonstrated that, when an exploratory vessel fished an area on a preselected grid of points and a commercial fisherman later fished this same area, but operated only in those places where organisms were most abundant, the catch rate of the fisherman was always higher than that of the exploratory vessel. This axiom is valid only under the conditions given by Stark and Slack-Smith. If, however, the exploratory vessel simulates commercial fishing only in the best locations, then its catch rate should be similar to that of an individual commercial fisherman who later fishes that area. Under this latter condition, however, the catch rate of the exploratory vessel can be expected to be considerably greater than that of any individual vessel within a large fleet fishing the same area at a later date. In fishing for shrimp of the genus Penaeus in the better portions of a newly discovered area, the catches of a single vessel must be extremely large to indicate the presence of a stock of sizeable magnitude. The point here is that the catch rate of a vessel is influenced by its competition.

About 10 years ago I wrote a brief note (Anonymous, 1959) that illustrates this point. This article described catches of Penaeus shrimp made by fishermen along the west coast of Mexico on virgin or nearly virgin grounds which later supported a substantial fishery.

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[3] Hymenopenaeus robustus is the only species of deep-water shrimp considered. I am grateful to Harvey R. Bullis, Jr., for allowing me to study various papers (now in press) authored by him and members of his staff concerning some of the results of exploratory operations in the region.

Because the note has been repeatedly overlooked, and because I had to do considerable research to uncover the material, I propose to bring it to life again and quote a part of it here: "The Japanese fishing vessel MINATO MARU, in 21 consecutive days of fishing along the virgin coast of Sinaloa, Mexico, in May 1936, caught 92 074 lb (41.8 metric tons) of shrimp (headless). The average daily catch was 4 384 lb (1 989 kg) of tails. The MINATO MARU fished a V. D-type net with a mouth (not including wings) of 20 m (about 65.5 ft). This phenomenal catch when compared with current yields per boat helps to answer the question 'What is a good virgin shrimp fishing grounds?'

"Some 10 years later on these same grounds, when fishing intensity had increased considerably, but was still not extremely intense, a group of 8 small boats operating between August 1946 and May 1947, caught a daily average of more than 1 000 lb (454 kg) each of headless shrimp. These boats were between 28 and 38 ft (8.5 and 11.6 m) in length, with 40 to 55 hp gasoline engines, and hauled nets between 30 and 45 ft (9.1 and 13.7 m) along the lead line. They fished an average of 12 hours a day, returning to port each night."

Although there was not much more to the note than this, I thought the readers would infer its import. Obviously, they did not, so now I shall add two short paragraphs to emphasize what I intended the note to convey.

By 1956 the shrimp fleet on the west coast of Mexico had grown to about 500 boats. Fishing intensity had increased considerably and the Mazatlán, Sinaloa, fleet fished not only the coast of Sinaloa but also the coasts of Sonora, Nayarit, Baja California, Oaxaca, and Chiapas. The fishing season was 10 months or more - more, if one fished the Oaxaca-Chiapas grounds. Any owner of a modern boat in 1956 considered himself fortunate if his boat caught as much shrimp in 10 months as did the MINATO MARU during 21 days in 1936, and he would have been elated if the catch were equal to that of one of the small boats in 1946-47.

The MINATO MARU explored the virgin coast of Sinaloa and simulated commercial fishing. I do not know if the MINATO MARU fished 24 h a day, but assuming that it did, the hourly catch (headless) during the 21-day period was about 83 kg. Throughout the 10 month period in 1946-47, the catch rate of the eight small boats averaged about 38 kg each of headless shrimp per hour of trawling.

If you think you have discovered a large stock of Penaeus, please do not forget that the catch of the MINATO MARU amounted to about 2 metric tons of shrimp tails a day for 21 consecutive days. If you do forget, my present effort also will have been for naught.

I surely do not wish to leave the impression that I am opposed to exploratory fishing. I have merely pointed out some of the problems involved in the interpretation of data gathered solely from this type of research. In fact, I have used standing crop estimates in developing estimates of potential yield.

Obviously, however, more information than that provided by exploratory fishing is needed if good estimates of fishable stocks are desired. This additional information may be ecological, involving knowledge of the life history and the feeding and nursery areas of the species; it may be based on a comparison of the catch rates or landing data of the same or a similar species with those in another area where intensive fishing is in progress; or, as mentioned earlier, it may include the rates of growth, mortality, and recruitment.

The use of ecological data or catch data, or preferably a combination of them, usually does not require the sophisticated methods involved in arriving at rates, and frequently the combination can give fairly reliable estimates. It seems, therefore, that we need to start accumulating data on the first two subjects before we can project more accurately than now the fishable magnitudes of shrimp stocks in areas that are not heavily fished. The cooperative effort, which includes statistical, ecological, and life history studies, undertaken by the Governments bordering on the Caribbean Sea and FAO is an excellent approach toward this end.

You will notice that I have restricted my discussion to the genus Penaeus. This is because we know a good deal about its ability to withstand fishing pressure, its stock production, and the catches that have been made by exploratory fishing. Shrimp of this genus are relatively short-lived, rapidly growing, and highly fecund, with ability to withstand tremendous fishing mortalities. Probably Xiphopeneus should also be included. When we go beyond these two genera in the Carolina-Venezuela region, however, and particularly when we begin to deal with deep-water species, we are on dangerous ground. Little or no information is available upon which to make comparisons between standing crops and crop production for deep water penaeids.

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The preceding information and the great amount of exploratory fishing undertaken for shrimp in recent years by Governmental agencies and by private industry make it highly probable that no large stocks of Penaeus shrimp remain undiscovered in the region under consideration.

If we were to take a close look at the stocks of Penaeus in the Carolina-Venezuela region, I suspect we would find that, under present fishing conditions, practically all are being fished at or near their maximum productive levels. I strongly suspect, but cannot establish yet, that P. setiferus in the northern Gulf of Mexico has been overfished since about the mid-1940's. Overfishing of this species also may be occurring in other areas, and possibly P. schmitti is being overfished in the Gulf of Venezuela. These two shallow-water species of Penaeus rarely range into depths greater than 40 m, and in some locations the entire stocks, after recruitment, are subject to intensive fishing for the remainder of their lives.

The largest and presumably more fecund specimens of P. setiferus in the northern Gulf of Mexico inhabit the deeper portions of the range. When these shrimp, after undergoing extremely intensive fishing in the estuaries and near-shore coastal waters, move into depths beyond 18 m, they encounter the intensive fishery for P. a. aztecus, which extends to about 80 metres. As a consequence, adults of P. setiferus in the northern Gulf of Mexico are subject to intensive fishing throughout their bathymetric range. They have no refuge areas for spawning reserves.

The distributions of the U.S. stocks of P. a. aztecus and P. d. duorarum in the Gulf of Mexico, in relation to the fisheries, are very different from that of P. setiferus in the northern Gulf. Large numbers of adult P. a. aztecus range into depths considerably greater than those frequented by most of the fishing fleet, and consequently, there still is a reserve spawning supply. P. d. duorarum not only moves into depths greater than those of the present fishery, but also large numbers of this species inhabit the region between the Sanibel and Tortugas fishing grounds. This region cannot be fished intensively because of corals and sponges; consequently, this species also has a spawning reserve.

Our present knowledge allows us only to speculate as to what would happen to these stocks of brown and pink shrimp if a gear were developed or if the economics of the fishery were such that these spawning reserves became heavily fished.

4 POTENTIAL INCREASES IN SHRIMP PRODUCTION

We have evidence that the production of Penaeus shrimp in waters of the United States could be increased appreciably, providing it were possible to reduce the number of small shrimp that are being taken. This evidence, although somewhat preliminary, is based on rates of growth and natural and fishing mortality derived from carefully controlled mark-recapture experiments. We estimate that the U.S.A. could increase its annual landings of Penaeus shrimp from its own waters by about 15 000 to 40 000 metric tons if fewer small shrimp were taken. These estimates, of course, are subject to revision as our research progresses.

I have no idea what comparable research on Penaeus in other areas of the Carolina-Venezuela region would reveal, but I suspect it would disclose that landings in some areas could be increased considerably. This assumption suggests that even with Penaeus we cannot now make reliable projections of maximum yields.

How one goes about reducing the capture of small shrimp is another story, not relevant here, because usually there are economic, sociological, legal, and political problems to be solved. Because these problems may be solved eventually, I included our estimates for increased landings in the U.S.A. in Table I. Similar estimates for other countries were not included because, as far as I know, none exist.

When we consider the other shallow-water forms, Xiphopeneus kroyeri and Sicyonia brevirostris are apparently the only two that have immediate potential for commercial expansion. These shrimp are smaller than Penaeus and are not now of great commercial interest. Because the demand for Xiphopeneus riveti from the Pacific coasts of Central America and northern South America is increasing, however, more use of Xiphopeneus from the western Atlantic can be expected. The three most likely areas for increased production of the seabob are in the Gulf of Mexico, Nicaragua, and near the mouths of the Orinoco River in eastern Venezuela.

Fisheries on the stocks of rock shrimp, Sicyonia brevirostris, are less likely to develop as soon as those for the seabob. The reasons are: (a) their flavour is different from that of the shallow-water commercial penaeids; (b) the shell is much harder and more difficult to peel than that of other shallow-water penaeids; and (c) the stocks probably are not large. Bullis, Carpenter, and Roithmayr (in press) estimated a standing crop of about 2 500 metric tons along the east coast of Florida, and there probably are comparable amounts in the northwestern Gulf of Mexico and on the Campeche grounds.

The deep-water shrimp extend over such vast regions that their stocks appear to be relatively large. These stocks, however, are not sufficiently concentrated to permit commercial fishing with known gear at this time except in a few locations. The only deep-water species that has been fished commercially in the Carolina-Venezuela region is the royal red shrimp (Hymenopenaeus robustus). This species has been fished sporadically on the three known grounds for a number of years, but more attention appears to have been paid to it in the past 6 years than previously.

Thompson (1967) cited the exceptional catch of about 77 metric tons (headless) of royal red shrimp by the commercial fishing vessel TERRY ANN on the St. Augustine grounds during the first 10 months of 1963. The only recent data I have available pertain to the Dry Tortugas grounds. In 1966, commercial fishermen caught about 11 metric tons (headless) in 890 hours of trawling on these grounds. The rate of catch was about 12 kg/hour. In 1967 on these same grounds, they caught about 14 t in 2 000 hours of trawling, which amounted to a rate of about 7 kg/hour. This drop in catch rate suggests a stock of small size, but the data are not adequate for such a conclusion.

Thompson (1967) mentioned the difficulties in fishing for royal red shrimp, but there also are some marketing problems. This species, like the rock shrimp, has a distinctive flavour and it must be boiled differently than Penaeus to give it proper texture. Bullis, Carpenter, and Roithmayr (in press) estimated the annual standing crop on the three known grounds to be about 700 metric tons.

Four other deep-water penaeids - Aristaeomorpha foliacea (Risso), Aristeus antennatus (Risso), Penaeopsis megalops (Smith), and Plesiopenaeus edwardsianus (Johnson) - and the pandalid, Plesionika edwardsii (Brandt), have been reported on numerous occasions throughout the region by Bullis and his co-workers. None of these except Penaeopsis megalops (which is small) was in concentrations sufficient to support a commercial fishery (Bullis, Carpenter, and Roithmayr, in press). These species have not been included in the estimates.

5 SUMMARY

Current landings for the western Atlantic Ocean between North Carolina, U.S.A., and the Orinoco River, Venezuela, are estimated at about 125 000 metric tons. Estimates of potential landings range from 160 000 to 185 000 tons. If 15 000 to 40 000 t from the U.S.A. that might eventually accrue by changing present management procedures are not included the potential production we can expect by increasing fishing in some localities and by fishing species not now utilized is about 145 000 t - or about 20 000 t more than are now being landed.

We can expect only about a 15 percent gain in landings by increasing fishing effort, and much of this gain is highly speculative. Improved management, however, can result in a gain in the U.S.A. alone of 15 000 to 40 000 tons. This represents an increase of between about 10 and 30 percent. The U.S. landings are about 60 percent of the total for the Carolina-Venezuela region. Since I do not know what improved management might accomplish in the remainder of the region, I have not taken it into account in estimating potentiallandings; the projections also do not include possible gains from shrimp mariculture.

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PROGRESS IN SHRIMP MARICULTURE IN THE UNITED STATES[1]

by

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Shrimp at present are not reared for commercial production in the United States. There are, however, numerous governmental, academic, and commercial organizations engaged in shrimp maricultural research, and the pace of research has accelerated in the last 2 years. As a result, we can probably expect some commercial production in the near future.

The main impediment to research on shrimp production in ponds and natural impoundments-has been a lack of postlarvae for stocking. This problem is all but solved. The Akima International Development Corporation and our Laboratory now possess the technology required to produce large quantities of postlarvae and undoubtedly others will have it soon.

At our Laboratory in Galveston, we have reared through the larval stages and beyond, the three major commercial species of *Penaeus* of the United States - the brown (*Penaeus aztecus aztecus*), the white (*P. setiferus*), and the pink shrimp (*P. duorarum duorarum*). Several less important species of shrimp, including *Sicyonia brevirostris* and *Xiphopeneus kroyeri*, as well as the stone crab (*Menippe mercenaria*) also have been cultured.

We have developed means of hatching and culturing to postlarvae large numbers of shrimp at almost any time of the year. At present, we obtain about 50 000 postlarvae from the spawn of a single female in about a 1 000-l culture tank. Three of these tanks are shown in Figure 1. Because it takes only about 14 days from spawning to postlarvae, one such culture unit could produce many thousands of postlarvae in a year.

Laboratory experiments indicate that, with carefully controlled conditions, the number of postlarvae can be increased to more than 50 000 per culture tank. Survival of brown shrimp larvae is increased by holding nauplii at 24°C and then, as development progresses, gradually increasing the temperature to 32°C.

The density and quality of food are also important in determining the number of larvae that can be cultured in a given volume of water. Survival appears to be greatest when food is maintained at or slightly below optimum levels. Excess food seems to cause mortality, whereas food levels somewhat below optimum appear to cause a decline in the rate of growth, but not extensive mortality.

Postlarvae are hardy and can be transported easily from one place to another. For shipment, they are gradually adjusted to water of about the same salinity and temperature as that of the recipient location. They are then placed in plastic bags with this adjusted water and supplemental oxygen is added. The bags are sealed and placed in styrofoam boxes which are then sealed. For experimental use about 80 000 postlarval brown shrimp were flown by private plane from Galveston, Texas, to Grande Terre Island, Louisiana, in boxes containing as many as 10 000 shrimp in 8 l of water. Although transport time was 6 h, mortality was estimated at less than 1 percent. The same technique has been used to ship, by commercial airline, postlarval brown shrimp from Galveston, Texas, to Tallahassee, Florida, and pink shrimp postlarvae from Miami, Florida, to Galveston, Texas. One box, containing 5 000 postlarval brown shrimp, was in transit 17 h with negligible mortality. This experience suggests that when shrimp culture is proven to be economically feasible, a few hatcheries may serve the needs of many shrimp farms. Research, however, has not yet reached the stage where we would recommend hatcheries other than for experimental purposes, but the day for the commercial hatchery may not be too far in the future.

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[1] Contribution No.283 from the Bureau of Commercial Fisheries Biological Laboratory, Galveston, Texas, 77550

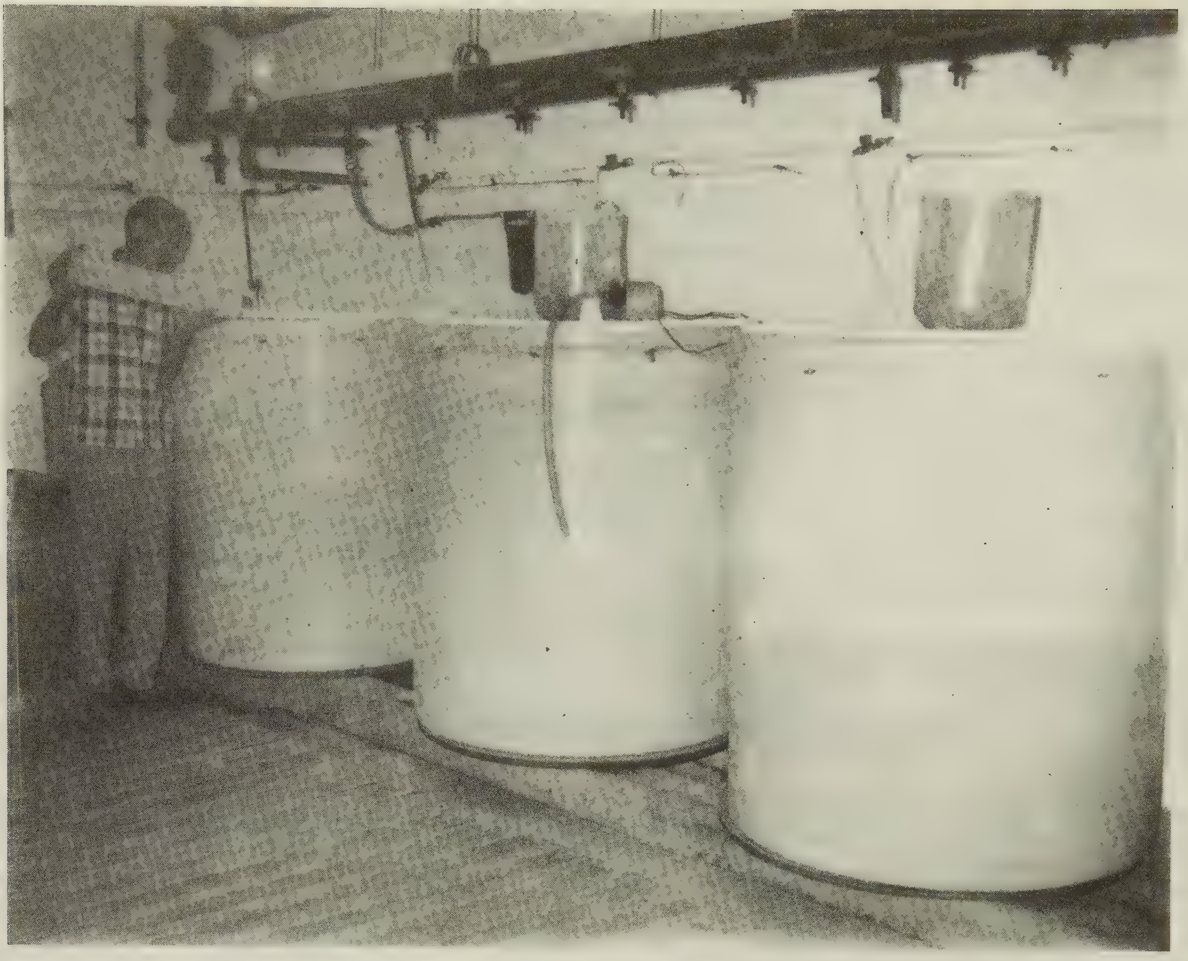

Fig. 1 Three tanks of 1 000-1 capacity in which larval shrimp are reared at the Bureau of Commercial Fisheries Biological Laboratory, Galveston, Texas

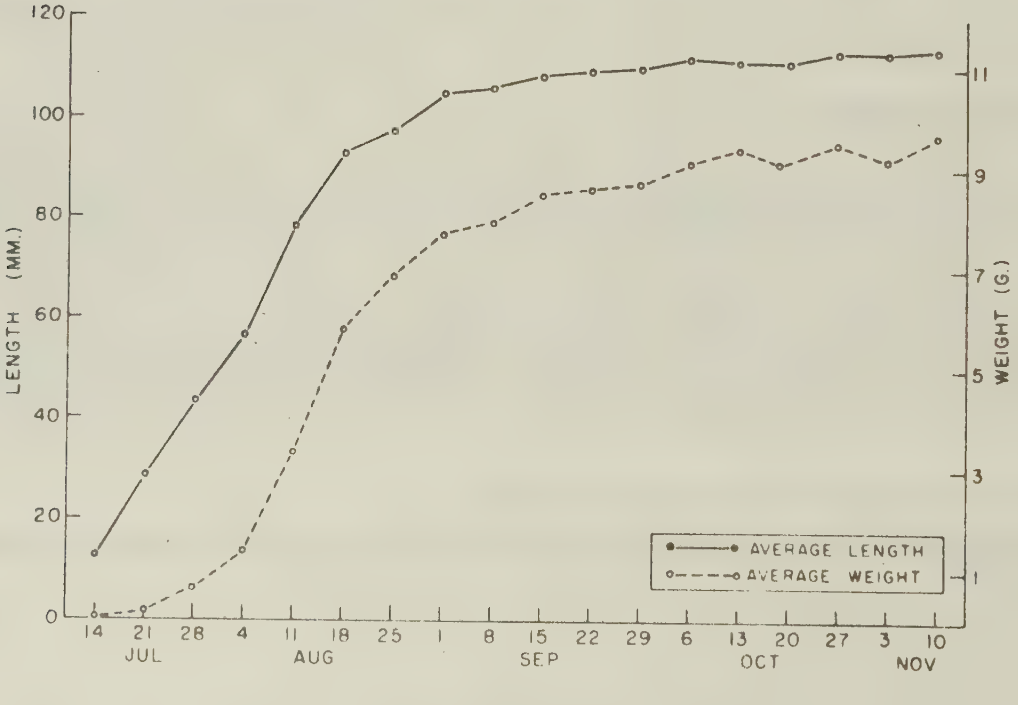

Fig. 2 Growth of white shrimp over a 4-mo period in 1966

Progress in our research to culture shrimp in ponds also has been encouraging. At our Laboratory, we have demonstrated that postlarvae can be grown rapidly in ponds to subadult size without supplemental feeding. For 3 consecutive years, shrimp growth was similar to that shown in Figure 2. The shrimp in this experiment were white shrimp that had been spawned in the laboratory. Placed in the pond as 12 mm postlarvae at about 38 000 to the pound, they grew to 92 mm or about 78 to the pound (heads-on) in 5 weeks. Growth above this size, however, was slow.

Supplemental feeding will accelerate growth of the larger shrimp, but their growth still does not approach that of wild shrimp. Foods such as cornmeal and pelleted rabbit and trout foods have been used in ponds, but have supported little or no growth in laboratory experiments. Shrimp, nevertheless, can be grown to a large size in ponds. We now have one pond containing 1-year-old shrimp that average 21 shrimp to the pound, heads-on.

Survival rates of 90 percent or above can be expected with proper pond management. One of the biggest problems facing those doing pond-culture work has been mortalities caused by oxygen deficiencies, but this problem should not be hard to solve. We have installed an aeration system in our ponds that apparently has eliminated this problem.

With our present knowledge and with supplemental feeding, yields of about 560 kg per ha of 31- to 40-count heads-on shrimp should be possible in growing periods of 100 to 120 days. In the south-eastern United States, it should be possible to harvest two such crops a year for an annual yield of about 1 100 kg per ha which, when sold for human consumption, would be worth about $890 per ha. With only a slight improvement in weight gains, 26- to 30-count heads-on shrimp could be obtained and the annual yield would increase to about $1 000 per ha. This figure would be comparable to catfish farming where annual yields are presently averaging about $970 per ha.

Culture of shrimp as live bait for sport fishing could be more profitable. As stated previously, postlarvae can be reared to bait size (about 80 mm) in 4 to 6 weeks. If a shrimp farmer took advantage of the heated effluent from power plants, he could culture shrimp throughout the year. With controlled temperature conditions and adequate facilities, it might be possible to harvest at least six, 450-kg-per-ha crops of bait per year. Bait shrimp in Texas usually sells for a minimum of $1.45 per kg wholesale, but during the winter they are worth as much as $5.50 per kg wholesale.

If calculated at the lower figure, the value per ha per hear would be about $3 900. The demand for bait shrimp is limited, but those culturing bait shrimp probably would develop knowledge that could be applied to the culturing of shrimp for human consumption.

After this somewhat optimistic presentation on shrimp culture, perhaps we should look at some of the cost aspects and at some of the problems about which little is known and much research is needed. You undoubtedly have already noticed that, although we have given some yield estimates, we have not presented any cost estimates. They were omitted deliberately because practically all shrimp cultural efforts in the United States are still in the experimental stage, particularly with respect to pond culture. In the near future, we will develop some cost estimates on larval culture, but cost estimates on pond culture probably will have to come from the other agencies involved in this research; we do not have the necessary pond facilities. Pond costs should include not only the production costs, such as pond construction, water supply, and feeding, but also harvesting and marketing costs as well as cost of land. Another cost not to be overlooked involves the economic and sociological effects that extensive pond culture might have on existing fisheries.

At our present stage of development the problems we are encountering in our research undoubtedly are more basic and of greater importance than are cost estimates. A list of some of these problems, but not their order of importance, follows:

(i) We still depend on wild stocks for a supply of ripe shrimp. Methods of inducing shrimp to mature and spawn under controlled conditions should be developed as well as techniques for regulating the time of spawning so that eggs can be obtained when they are required.

(ii) An economical prepared food that will support the rapid growth of shrimp in ponds is needed, as is a food that contains nutrients suitable for allowing shrimp to develop to sexual maturity in confinement.

(iii) The cycling and orderly control and improvement of natural shrimp foods in ponds should be known to determine whether it would be more economical to provide either natural or prepared foods, or a combination of both.

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(iv) We must consider the possibilities of shrimp parasites and diseases. Little is known about them, but most certainly they will present problems when shrimp are maintained in confinement.

(v) We have the great and completely unexplored domain of genetical research to create rapid-growing and disease-resistant strains.

(vi) Finally, because a pond contains depth in addition to a surface and a bottom, the monoculture of bottom-living shrimp should not be the ultimate objective. Eventually, we must be able to grow organisms for human consumption throughout the entire water column.

For the most part, we have limited the material presented to work accomplished and some of the thoughts we have at our Laboratory. Our organization, however, is not the only one working on shrimp mariculture. Within the next year, at least 12 governmental agencies or universities will be conducting research on this problem in the United States. At least four private concerns are now in operation and others are planning to start in the near future. We have attached, as an appendix, a list of these organizations and, as far as they were obtainable, their objectives and facilities.

APPENDIX

Organizations in the United States Involved in Research on Shrimp Mariculture

A. Governmental and University

1. Bears Bluff Laboratories, Route 1, Box 39, Wadmalaw Island, South Carolina 29487.

Research objectives are: (a) to experiment with different types of food to find the most economical for use in shrimp culture; (b) to develop the proper technique for spawning shrimp in captivity with emphasis on the use of hormones to stimulate sexual development; and (c) to culture diatoms to be used as food for larval shrimp.

The Laboratory has 11 ponds from 0.04 to about 1 ha. Most are being used for shrimp culture. A large greenhouse contains six 2.6 x 3.6 m, eleven 340-1 tanks, and two 2 268-1 circular tanks. Four of the large tanks have heat exchangers for temperature control.

2. Bureau of Commercial Fisheries Biological Laboratory, Building 302, Fort Crockett, Galveston, Texas 77550.

BCF research on shrimp mariculture is centred at the Galveston Laboratory. Objectives of this research are: (a) to develop methods to induce shrimp to spawn under controlled conditions; (b) to improve methods of larval culture; (c) to develop a processed food that will support rapid growth under controlled conditions; (d) to develop methods to control or modify environmental factors for maximum production of natural shrimp foods; (e) to breed selective strains of fast-growing shrimp that are tolerant of low temperatures and resistant to disease; (f) to establish experimental populations of shrimp in estuaries to determine the feasibility of bolstering or renewing natural populations; and (g) to control undesirable predators, competitors, and parasites.

Research facilities include a recirculating sea-water system that houses a prototype hatchery, a greenhouse for algal culture, a circulating sea-water system, five 0.02-ha ponds, and a tidal lagoon. The earthen ponds are in the tidal zone and are filled by seepage and drained by pumping.

3. Florida Atlantic University, Boca Raton, Florida 33432.

Technical advice is supplied to industry.

4. Florida State University, Department of Oceanography, Tallahassee, Florida 32306.

Research on shrimp foods is conducted in the laboratory.

5. Gulf Coast Research Laboratory, P.O. Box 218, Ocean Springs, Mississippi 39564.

Research on the pond culture of shrimp will begin in the near future. Plans call for 3.2 ha of ponds with pumping facilities.

6. Louisiana State University, Baton Rouge, Louisiana 70803.

A 1-year study is designed to provide information on the feasibility of using salt-water marshes for intensive mariculture.

They have constructed five 0.04-ha ponds in the marsh for maturation studies. Four of the earthen ponds are 1.2 m deep and one is 3.0 m.

7. Louisiana Wild Life and Fisheries Commission Biological Laboratory, Grande Terre Island, P.O. Grand Isle, Louisiana 70358.

Research to date has concentrated on feeding and growth experiments in ponds. Future plans call for the establishment of a hatchery and studies on larval physiology.

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Research facilities include twenty 0.1-ha ponds, and one well-equipped laboratory. The ponds are above high tide level and are filled by pumping and drained by gravity. They are earthen bottoms and their sides are constructed of corrugated asbestos roofing material.

8. Francis T. Nicholls State College, Thibodaux, Louisiana 70301.

A 2-year project to study shrimp production in Louisiana salt-marsh impoundments under existing and managed conditions is in progress. Within a marsh, two study areas - one of 15.4 ha and the other of 6.9 ha - have been enclosed with earthen levees. Water flow is controlled by weirs.

9. Texas A & M University, College Station, Texas 77840.

Plans are being made for diversified mariculture projects that will involve shrimp, fishes, and other marine organisms.

10. Texas Parks and Wildlife Department, John H. Reagan Building, Austin, Texas 78701.

A salt-water pond experiment station and marine laboratory is under construction on a 16.2-ha site on Matagorda Bay near Palacios, Texas. This installation will have 21 ponds ranging from 0.1 to 1.6 ha. The ponds are above high tide and they will be filled by pumping salt water from the bay and fresh water from deep wells. They will be drained by gravity. Only a portion of the earthen ponds will be used to study shrimp culture.

11. University of Georgia, Sapelo Island Research Laboratory, Sapelo Island, Georgia 31327.

Research is conducted on pond culture and spawning. Facilities include two ponds - 0.1 ha and 0.2 ha - plus a well-equipped laboratory.

12. University of Miami, 10 Rickenbacker Causeway, Miami, Florida 33149.

Research includes growth studies in ponds in which water temperatures are controlled, larval culture, and food preference studies.

Seven ponds that range from 0.1 ha to 0.4 ha and a hatchery building were constructed recently at Turkey Point south of Miami. The ponds are above high tide, and are filled by pumping and drained by gravity. The ponds have marl bottoms and the sides are lined with rubber.

B. Industry

1. Akima International Development Corp., P.O. Box 2414, Panama City, Florida 32401.

Akima International has employed Japanese biologists and is adapting the Japanese methods of shrimp culture to the United States. They have cultured larvae of pink shrimp to postlarvae on a large scale, and they are now working to determine the best and most economical growing conditions.

2. Florida Seafood Growers, 29 E. Fairfield Drive, Pensacola, Florida 32501.

3. Marinus Laboratories, Inc., Melbourne, Florida 32901.

4. Sea Farms Inc., 3732 Flagler Ave., Key West, Florida 33040.

C. Industry Supporting Research on Mariculture

1. Armour and Company - University of Miami and Florida State University.

2. Florida Power and Light Company - University of Miami.

3. Louisiana Land and Exploration Company - Francis T. Nicholls State College.

4. United Fruit Company - University of Miami.

THE BLACKFIN TUNA (THUNNUS ATLANTICUS) AS AN UNDERUTILIZED FISHERY RESOURCE IN THE TROPICAL WESTERN ATLANTIC OCEAN

by

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Bureau of Commercial Fisheries Exploratory Fishing
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1 INTRODUCTION

The blackfin tuna (Thunnus atlanticus), a tropical pelagic species, is confined to the western Atlantic from southern New England to Rio de Janeiro throughout the Caribbean and Gulf of Mexico. It is the only species of tuna restricted to the western Atlantic and usually occurs at or near the surface in areas where the water depths are between 6 and 4 600 fathoms. It moves to higher latitudes with the warming of the water in summer but does so to a lesser degree than other tunas. Throughout the range schools of blackfin tuna are often seen at the surface mixed with schools of skipjack tuna, Katsuwonus pelamis (Mather, 1963). The surface activity of blackfin tuna facilitates close detection by sight or more distant detection through the presence of concentrations of birds.

2 BLACKFIN TUNA FISHERY

Brazil and Cuba are the only nations that now have commercial fisheries for blackfin tuna. These fisheries are restricted to the shelf area, not far from the coast, and the principal methods of harvesting are poles and trolling gear.

2.1 Blackfin tuna fishery of Brazil

In Brazil the fishery is carried out between Ponta do Moleque and Ponto da Cotia extending some 12 to 16 mi from shore over the area known as the "Paredes." Sailing vessels from Baia Formosa engage in the fishing, which begins just after sunrise and ends about sunset. Trolling lines with out bait are used to catch the fish.

Catches of blackfin tuna vary widely during the season, which extends from October to January. Catches are largest in November to December but decline sharply from mid-December to January. When fish are at the surface, a vessel can catch 40 to 50 blackfin tuna in a day. During the 1963-64 season, 194 589 lb of gutted blackfin tuna were landed (Table I).

Da Cruz and Pinto Paiva (1964) reported on the potential catch of blackfin tuna in Brazil. They hypothesized that if all the boats had fished every day of the 1963-64 season, the catch would have been 397 010 pounds. In other words, the actual catch was only 37 percent of the potential catch. They also mentioned that if surface trolling gear were replaced by purse seines, catches capable of sustaining a large cannery in the area of the Brazilian fishery might be realized.

TABLE I

Data on the 1963-64 blackfin tuna season in Baia Formosa, Brazil
(after da Cruz and Pinto Paiva, 1964: 5)

Year	Month	2-week period	Boats	Daily trips	Average trips	Total catch		Average weight	Catch per trip		Possible catch	
						Fish	Weight		Fish	Weight	Fish	Weight
			No.	No.	No.	No.	lb	lb	No.	lb	No.	lb
1963	Oct.	2nd	70	212	3.0	2 016	17 158.5	8.5	9.5	80.9	10 640	90 537
"	Nov.	1st	72	595	8.3	7 450	55 657.4	7.5	12.5	93.5	13 500	101 101
"	"	2nd	73	639	8.8	6 823	53 201.5	7.8	10.7	83.3	11 717	91 170
"	Dec.	1st	72	689	9.6	8 24	66 983.4	8.1	12.0	97.2	12 960	104 907
"	"	2nd	67	128	1.9	121	912.9	7.5	.9	7.1	965	7 555
1964	Jan.	1st	61	267	4.4	81	675.1	8.3	.3	2.5	275	2 216
Total or average				2 530*	33.7	24 730*	194 589*	7.9	9.8	76.9	50 057*	397 010*

* Figures marked with an asterisk are sums of columns

All weights refer to eviscerated fish

2.2 Blackfin tuna fishery of Cuba

In 1940 a live bait fishery for blackfin and skipjack tunas began in Cuba as an off-season activity for canneries, vessels, and fishermen, but in 1951 it became a year-round operation. The fishing grounds are within the territorial waters of Cuba from Point Tobaco on the north-west coast to longitude 80°W on the south-west coast. Fishing is done primarily along the sand banks about 5 mi from shore. Principal ports of landing are Nueva Gerona (Isle of Pines), La Coloma, and Los Arroyos de Mantua (Suarez-Caabro and Duarte Bello, 1961). Rawlings (1953) reported that on the south coast fish averaged 3-4 lb and blackfin dominated the catch whereas the northern coast fish averaged 6-8 lb and skipjack dominated the landings. This mixed catch of blackfin and skipjack was marketed as "bonito en aceite" supplying about 85 percent of the demand for tuna in Cuba. The typical vessel has a six-man crew - captain, engineer, cook, iceman, and two fishermen. The iceman chums with live sardines while the remainder of the crew fishes. The Japanese spray method is also used to concentrate the fish. Annual catches of blackfin averaged approximately 1 651 550 lb from 1949 to 1959, and production was highest in 1956 and 1957 (Table II).

TABLE II

Estimated blackfin tuna landings in Cuba, 1949-59
(after Suarez-Caabro and Duarte Bello, 1961)

Year	Total catch (all species)	Catch of blackfin and skipjack 1/	Catch of blackfin 2/
	lb	lb	lb
1949	1 174 189	1 056 770	708 036
1950	1 568 057	1 411 251	945 538
1951	1 711 742	1 540 568	1 032 181
1952	2 671 883	2 404 695	1 611 146
1953	2 785 415	2 506 874	1 679 606
1954	2 979 200	2 681 280	1 796 458
1955	3 034 150	2 730 735	1 829 592
1956	4 269 000	3 842 100	2 574 207
1957	4 250 000	3 825 000	2 562 750
1958	2 003 351	1 803 016	1 208 021
1959	3 680 795	3 312 716	2 219 520
Total			18 167 055
Average			1 651 550

1/ Estimate is based on 90 percent of the total catch

2/ Estimate is based on 66.67 percent of the catch of blackfin and skipjack

About 1962 Cuba acquired five purse seiners from Japan which were operated by the State Fishery Enterprise. In 1966, 23 seiners were purchased from Spain.

Fishing with a purse seine is done from two boats - the net boat, which sets the net, and the striker boat, which concentrates the school. After locating the school, the striker boat begins chumming with live bait. During the chumming, valves are opened to create spray to concentrate the fish at the stern. The vessel then proceeds to run in ever decreasing circles while the net boat sets the purse seine encircling the striker boat (Figure 1).

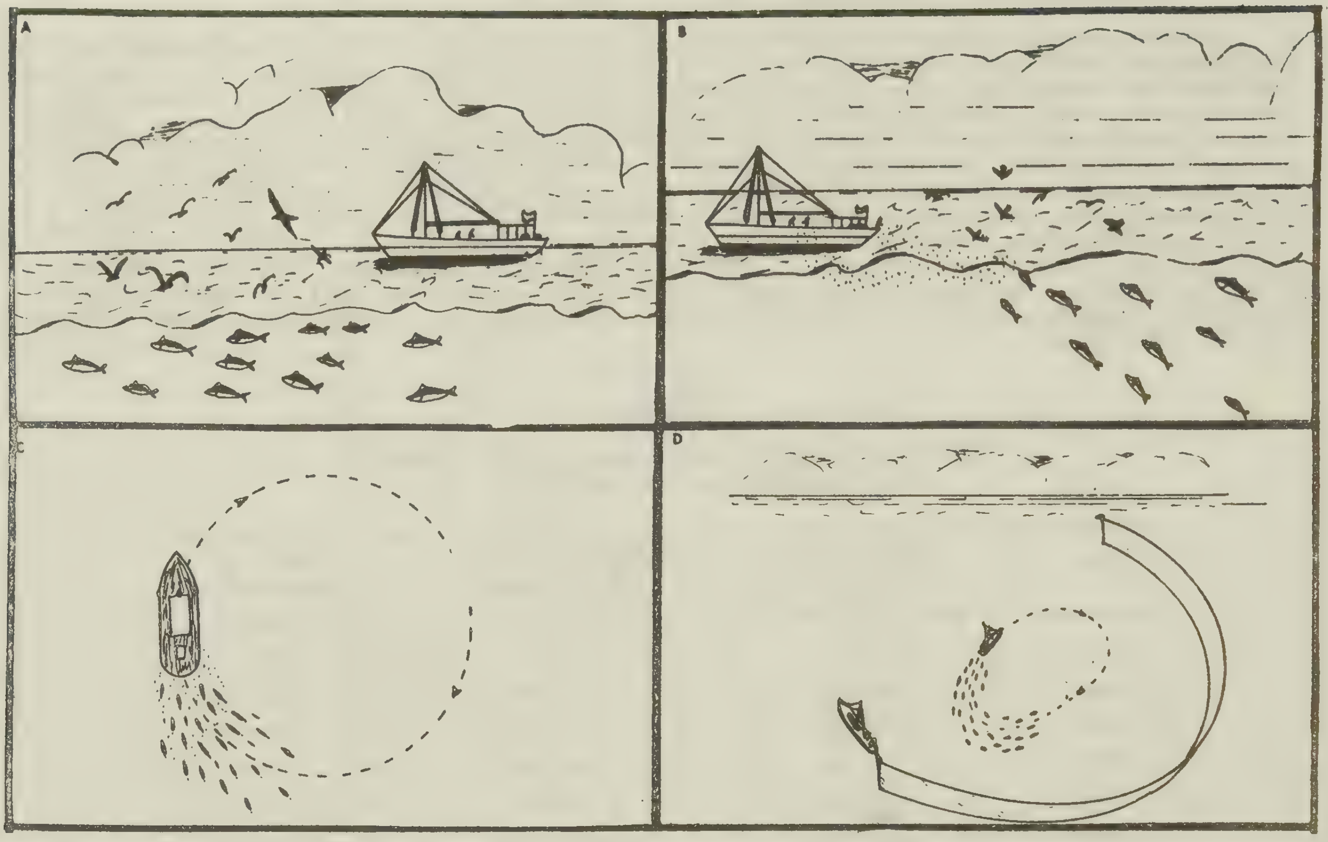

Fig. 1 Procedures followed in setting a purse-seine in the Cuban fishery (after Cubillas, 1961)

3 POTENTIAL FISHERY FOR THE UNITED STATES

Blackfin tuna have been observed in abundance from exploratory vessels of the Bureau of Commercial Fisheries in the western Atlantic, including the Gulf and Caribbean, since the beginning of exploratory operations by the Base at Pascagoula, Mississippi, in 1950. Although our data have been obtained incidental to other activities, they nevertheless indicate an unutilized and potential commercial tuna fishery for the United States.

Catches and sightings of blackfin tuna have occurred during deep-water shrimp explorations off the Mississippi River Delta area, in the northern Gulf of Mexico, and in the Atlantic and Caribbean. Catches were made mainly by trolling lines while vessels were steaming to the cruise area or while vessels were running from one station to another within the cruise area. Longlines have yielded few catches, this lack of success is attributed to the large hooks used (Bullis, 1955).

Exploratory catch data indicate that blackfin tuna range from 1 to 24 lb and 28 to 79 cm long (fork length). Average weight is 7.5 lb and average length is 54 cm. A length-weight relationship of the blackfin tuna is shown in Figure 2.

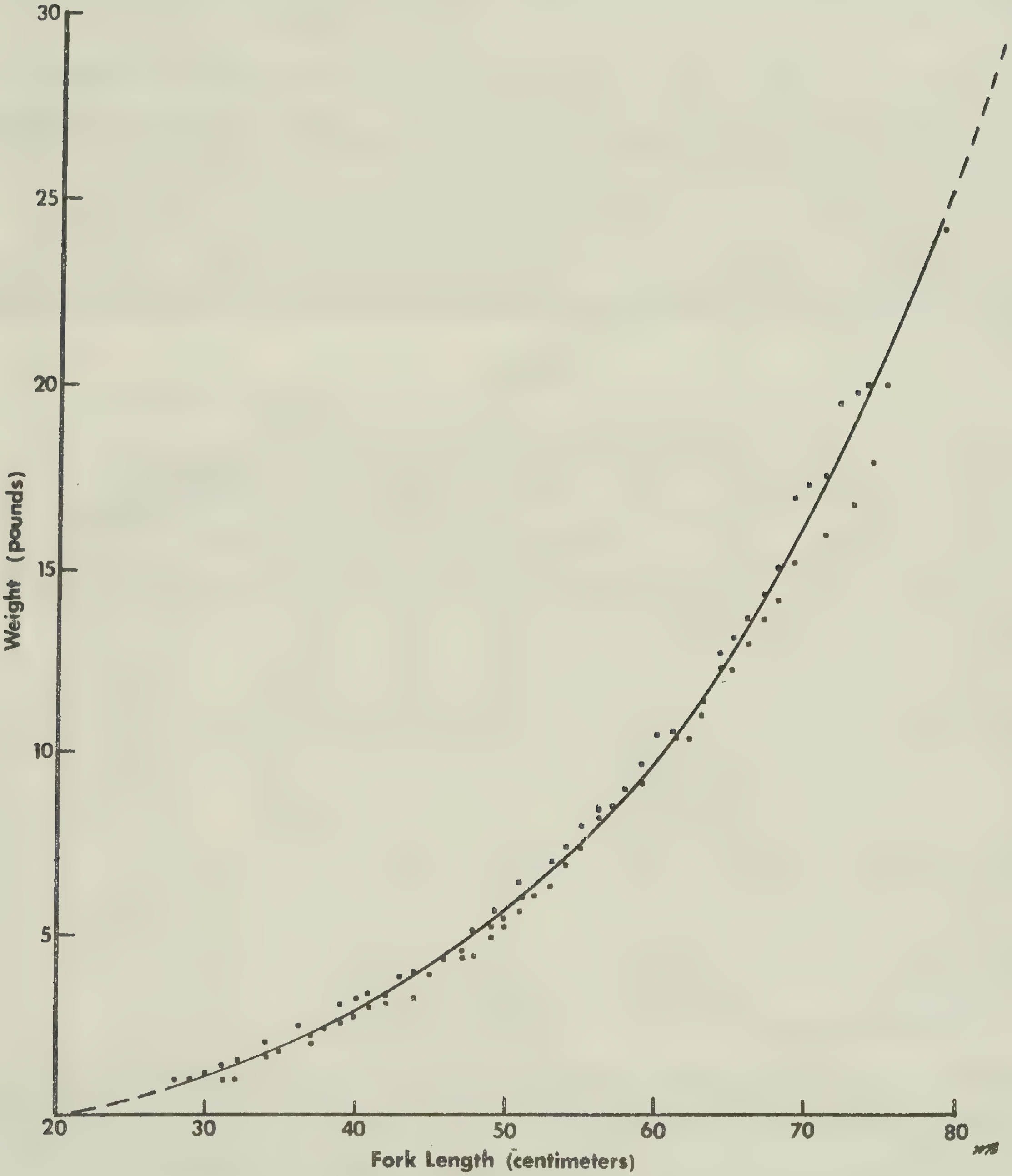

Fig. 2 Length-weight relation of the blackfin tuna (*Thunnus atlanticus*) based on 1895 specimens 28 to 79 cm in fork length (1-24 lb) from BCF exploratory data, the Cuban fishery (Suarez-Caabro and Duarte Bello, 1961:78), and the Brazilian fishery (da Cruz, 1965:35)

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According to Bullis and Mather (1956: 5), Rivas (1961: 131), and the data discussed herein, specimens of blackfin tuna over 25 lb are extremely rare. The largest blackfin tuna on record is a 34 lb specimen (89 cm in fork length) taken on rod and reel 35 mi off St. Petersburg, Florida (Rivas, 1961: 131). This specimen is in the fish collections of the University of Miami.

Exploratory catch is composed mainly of age groups II, III, IV, and V. These four age groups represent 91 percent of the total number of individuals studied and 75 percent of the total poundage.

The correlation between surface temperature and occurrence of blackfin tuna (Table III) indicates that 92 percent of sightings and catches occurred at temperatures from 78° though 86°F, and that 67 percent of these occur within 80°-82°F. Temperatures of 78°-86°F may be considered to indicate the highest probability of occurrence for blackfin tuna in a given area within its geographic range. In the Gulf of Mexico, the areas of most favourable temperatures vary according to seasons (Rivas, in press). Throughout the Gulf summer is the most favourable season. In the Caribbean Sea, however, favourable temperatures may occur throughout the entire year. In the northern Gulf, north of latitude 26°, only one school of blackfin was sighted in January through March during the 18-year exploratory period. In the Caribbean, 71 fish were caught with trolling gear during the same monthly and exploratory periods.

TABLE III

Monthly sightings and catches of blackfin tuna associated with surface temperatures

Month	Northern Gulf			Southern Gulf			Caribbean and adjacent areas		
	Sightings & catches	Temperature		Sightings & catches	Temperature		Sightings & catches	Temperature	
		Range	Mean		Range	Mean		Range	Mean
January	1	75	75				1	78	78
February							2	78-83	80.5
March							4	79-80	79.8
April				3	80	80	5	80-82	80.4
May	1	82	82	4	81-82	81.8	57	78-84	81
June	6	72-87	81.3				37	80-84	81.5
July	11	83-88	85.7				2	83	83
August	13	83-87	85.1						
September	8	82-86	84.4				2	84-85	84.5
October	1	79	79				8	83-85	84.1
November	1	76	76				3	82	82
December	5	75-76	75.8						

We studied the relation of 330 surface observations (school sightings and trolling and jackpole captures) to water depths. Highest concentration of blackfin at the surface (86 percent of observations) was in the areas where the water depths are between 40 and 1 500 fm, with a peak at 80 to 90 fm. Of the remaining 15 percent of the observations, 9 percent occurred where water depths were between 6 and 40 fm and 5 percent between 1 500 and 4 600. There were only four observations between 2 200 and 2 900 fm, none between 2 900 and 4 500, and only one between 4 500 and 4 600 at the Brownson Deep, north of Puerto Rico.

Our data indicate five major areas of occurrence as follows: off the Mississippi River Delta, Nicaraguan Shelf, Cuban coast, northern Lesser Antilles to east coast of Puerto Rico, and north-east coast of Brazil (Figures 3-7). Off the Mississippi River Delta blackfin tuna are abundant only from May to September although this area has been surveyed at other times of the year. During OREGON Cruise 115, 67 blackfin from 1.8 to 9 lb were taken by trolling gear off the coast of Nicaragua in January and February 1967. In May and June 1967, during OREGON Cruise 118, 245 blackfin were taken from some 23 schools around the Greater Antilles. The catch consisted of fish averaging 6½ lb for a total of 1 346 lb.

In addition, many dense schools of blackfin have been sighted throughout the Caribbean particularly off Pta de San Blas, Panama, on 19 October 1965. The large concentrations of blackfin in a given area may well be the result of a greater number of exploratory cruises in the area. Likewise, the lack of additional areas of abundance may well be attributed to the absence of exploratory effort. The number of sightings and catches, however, is indicative of unutilized commercial potential throughout the Gulf and Caribbean near existing fleets and canneries.

Several factors make blackfin tuna suitable for marketing it as a canned product in the United States. The relatively small size of the blackfin (average, 7.5 lb) facilitates handling aboard the vessel as well as in the cannery. Test packs have proved to be extremely palatable (Iwamoto, 1965). Recently the U.S. Food and Drug Administration approved the labelling of blackfin tuna as light meat tuna.

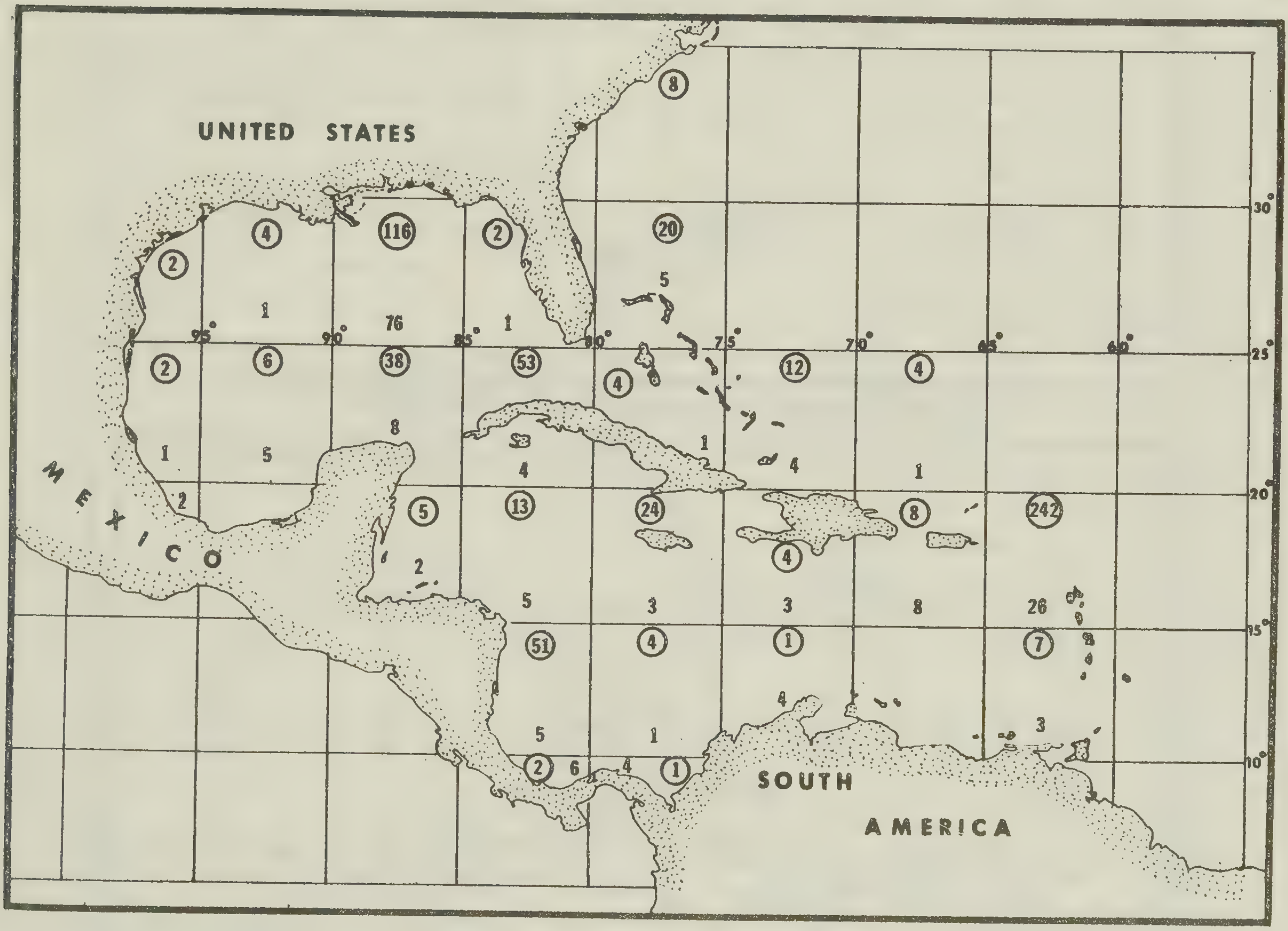
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Fig. 3 Total catches (circled numbers) and sightings of blackfin tuna in the Gulf of Mexico, Caribbean Sea, and adjacent areas, 1950–68

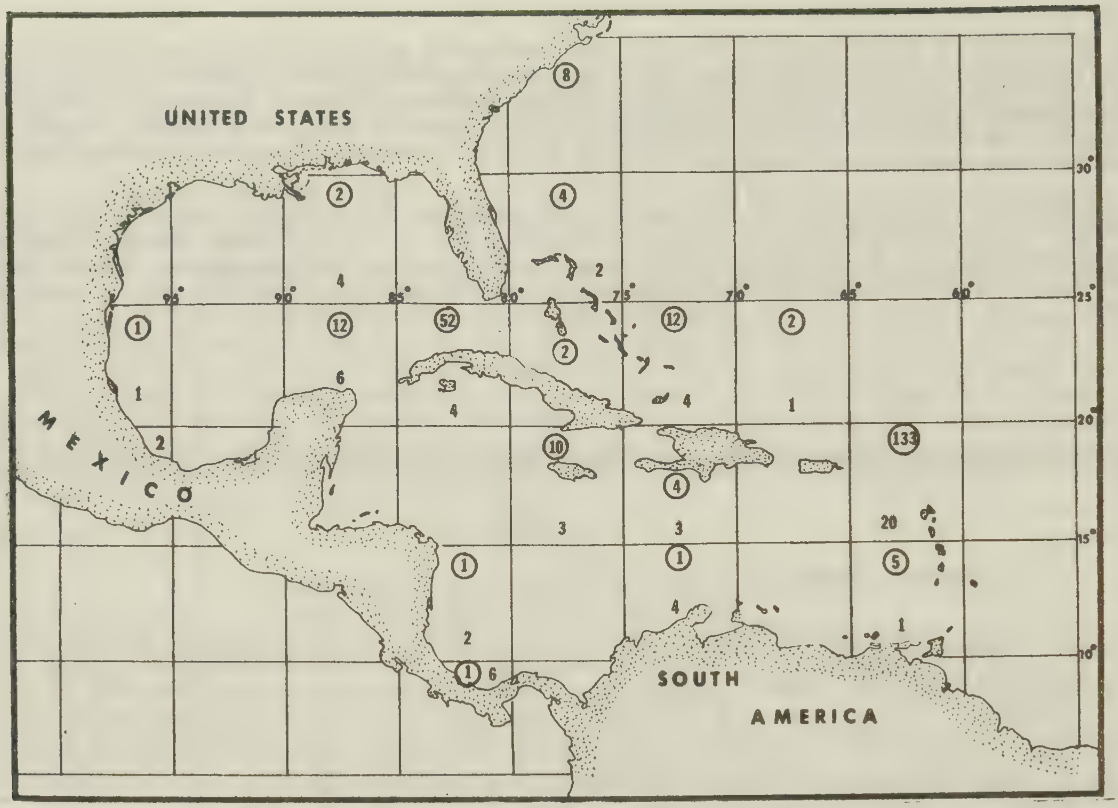
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Fig. 4 Spring catches (circled numbers) and sightings of blackfin tuna in the Gulf of Mexico, Caribbean Sea, and adjacent areas, 1950–68

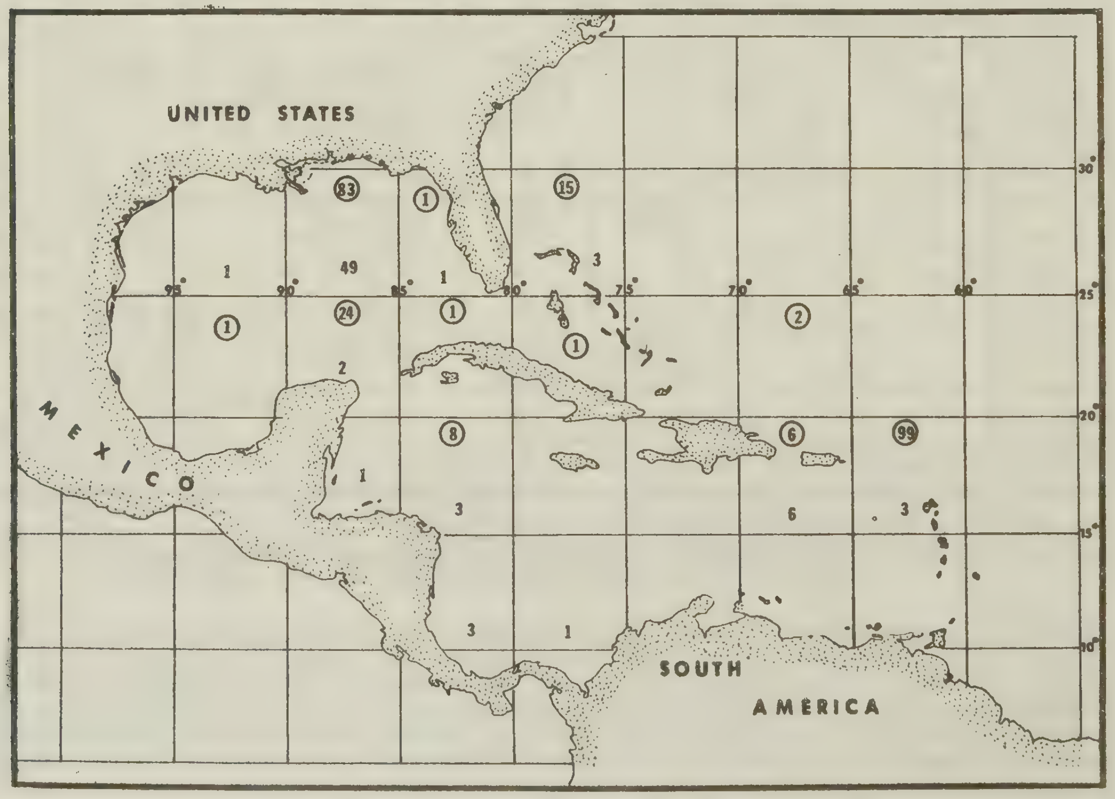
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Fig. 5 Summer catches (circled numbers) and sightings of blackfin tuna in the Gulf of Mexico, Caribbean Sea, and adjacent areas, 1950–68

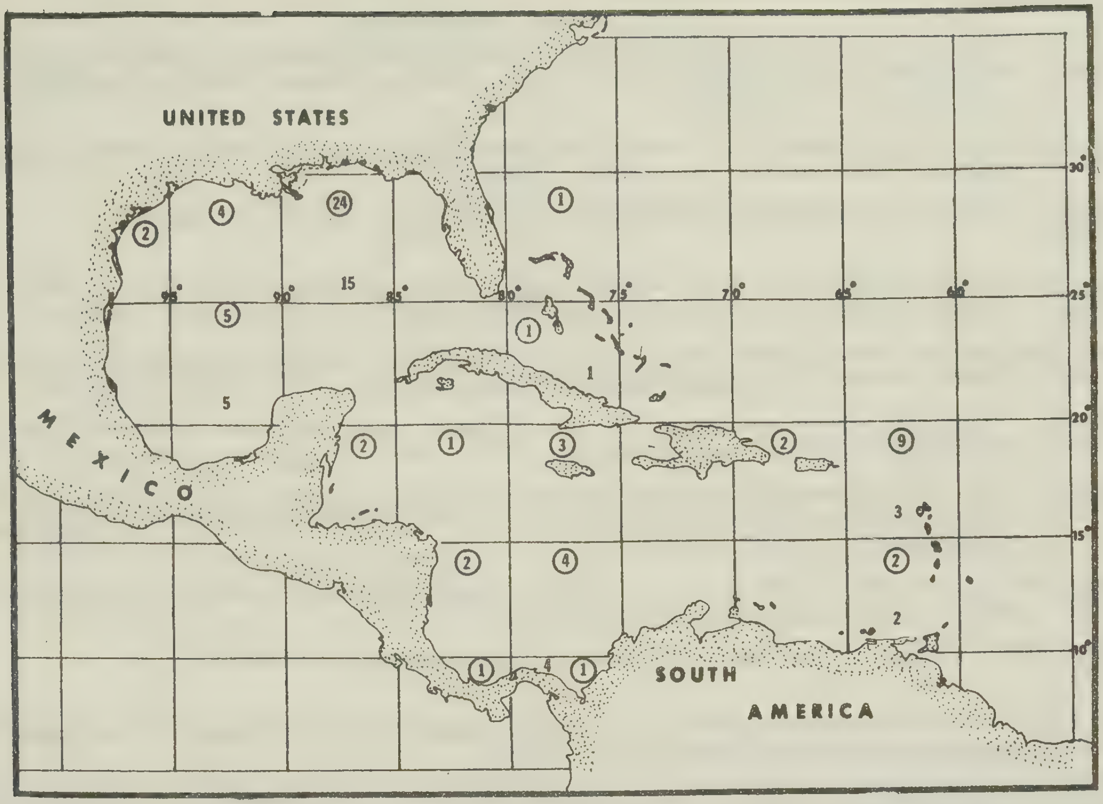
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Fig. 6 Autumn catches (circled numbers) and sightings of blackfin tuna in the Gulf of Mexico, Caribbean Sea, and adjacent areas, 1950-68

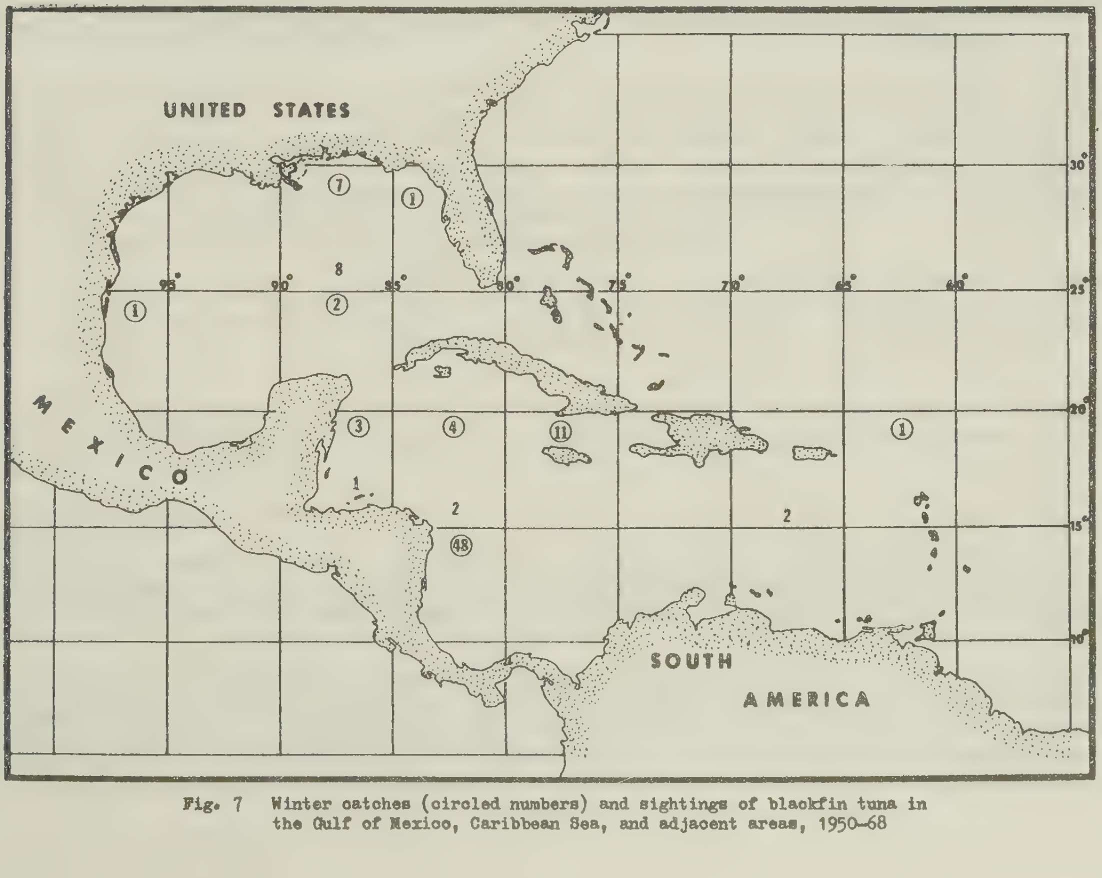
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Fig. 7 Winter catches (circled numbers) and sightings of blackfin tuna in the Gulf of Mexico, Caribbean Sea, and adjacent areas, 1950-68

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4.28

ESTADO ACTUAL DE LA BIOLOGIA Y CULTIVOS DE MOLUSCOS COMESTIBLES EN VENEZUELA

por

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1 INTRODUCCION

En todos aquellos países en que se ha alcanzado un cierto grado de evolución en las pesquerías, el sistema de cultivar o criar artificialmente moluscos ha tenido gran éxito y extensa significación económica, pués derivan de él utilidades que representan millones de dólares al mismo tiempo que constituye una fuente importante y permanente de trabajo. Además se ha demostrado que las medidas legislativas encaminadas a la conservación de este tipo de recurso son insuficientes para mantener los bancos naturales a un nivel adecuado de explotación.

Tanto las vedas temporales como la fijación de un tamaño mínimo comercial son de difícil aplicación y de resultados siempre insuficientes cuando no ineficaces (Andreu 1962). Sin embargo, Venezuela a pesar de disponer de condiciones ambientales excelentes y abundantes especies comerciales, ignoró hasta 1962 aspectos importantísimos relacionados con la biología y el cultivo dé especies de moluscos comestibles como el mejillón (*Perna perna*), ostión (*Crassostrea rhizophorae*), ostra perlífera (*Pinctada imbricata*) y continua ignorando aspectos y posibilidades correspondientes al Guacuco, Chipi-Chipi y Pepitona, respectivamente *Tivela mactroides*, *Donax* sp. y *Arca zebra*.

A partir de 1962 el Gobierno Nacional por intermedio del Instituto Oceanográfico de la Universidad de Oriente y posteriormente en 1964, mediante el C.I.P. (M.A.C.) ha venido tratando de iniciar una explotación de estos recursos que esté normada por recomendaciones derivadas de estudios científico-técnicos.

El presente informe sumariza las investigaciones y experiencias realizadas y que se realizan actualmente como parte del esfuerzo organizador y orientador para la explotación de algunos de estos moluscos por medio de cultivos.

2 MEJILLON: *Perna perna* (Linneo)

Para enlatado y consumo en fresco, se obtiene tanto de los lechos naturales situados en la costa oriental del Estado Sucre (Fig. 1) como de algunas balsas particulares y oficiales situadas en el Golfo de Cariaco del mismo Estado. La captura anual comprendida entre los años 1960-1967 se indica en el Cuadro I.

En Venezuela, la modalidad de cultivar mejillón en balsas por medio de soportes colgantes (cuerdas) de sisal o esparto importado fué iniciada por particulares en 1960, siendo posteriormente el Instituto Oceanográfico en el año 1962 el encargado de iniciar por intermedio del Dr. B. Andreu los estudios científicos y técnicos que condujeran a un verdadero cultivo. Para la fecha, dicho Instituto cuenta con una balsa piloto gigante para 1 000 cuerdas de esparto importadas de España, fondeada en Turpialito

(Golfo de Cariaco). La estructura y los flotadores de la mencionada balsa son de madera, pero estos últimos están revestidos de concreto. Desde 1962, fecha en que se inició el anteproyecto "Instalación de parques pilotos para cultivos de ostiones y mejillones en el Golfo de Cariaco y costas adyacentes" hasta el presente, el Laboratorio de Biología Pesquera de ese Instituto ha ido contribuyendo (aúnque con limitaciones debidas a la escasez de personal científico-técnico) con trabajos de investigación que aclaran algunos puntos oscuros que en un principio incidieron negativamente sobre las cosechas esperadas. Por otra parte, el Ministerio de Agricultura y Cría por intermedio del C.I.P. inició en 1964 un plan especial para los Estados Sucre y Nueva Esparta con la finalidad de elevar el nivel de vida de 100 familias de pescadores, así como de racionalizar la explotación del mejillón, diseñandose para tal fín una balsa económica, pequeña (Fig. 2) (aproximadamente 1 633 B^s), para 100 soportes y duración de cinco años a base de una estructura con maderas de la región, guatacare (*Baureria cumanensis*) y Mangle (*Rhizophora mangle*) unidas por cabillas y flotadores de material plástico (Styrofoam). Como soportes para la adherencia de la semilla se utilizó varas de bambú (*Bambusa vulgaris*) de 4 m de longitud en sustitución de las cuerdas de sisal o esparto. De las dos cosechas anuales calculadas (150 000 kg) para las 30 primeras balsas construídas y fondeadas en San Antonio, solo se logró cosechar a los 15 meses 62 000 kg debido a las siguientes fallas:

(a) Destrucción parcial de las estructuras y soportes (bambúes) por acción de perforadores pertenecientes a la Superfamilia Adesmacea (*Teredo* y *Bankia*).

(b) Destrucción progresiva (parcial) de los flotadores de plástico por acción de Crustáceos Decápodos (Fig. 3); se encontraron ejemplares pertenecientes a las familias Grapsidae, Majidae, Xanthidae y Parcellanidae.

(c) Fluctuaciones imprevistas en el grado de gordura requerido (20%) lo que fué motivo de que los industriales rechazaran la cosecha en varias oportunidades.

Con las investigaciones realizadas, las que se realizan y la experiencia adquirida se están corrigiendo fallas para garantizar en el futuro el mayor éxito posible.

CUADRO I

Captura de mejillones en toneladas y miles de bolívares

AÑOS	TONELADAS	MILES DE BOLIVARES
1960	141	94
1961	149	106
1962	188	134
1963	212	133
1964	186	101
1965	-	-
1966	256	185
1967	185	134

3 OSTION: *Crassostrea rhizophorae* (Guilding)

De modo natural los ostiones se encuentran adheridos fuertemente a las raíces aéreas del mangle rojo (*Rhizophora mangle* Linneo), (Fig. 4) en lagunas costeras de localidades en donde la salinidad es poco fluctuante (cerca de 36,5°/oo) como en los casos de la Laguna Grande del Obispo, la Bahía de Mochima y la Laguna de la Restinga, respectivamente en los Estados Sucre y Nueva Esparta, o bien, a raíces de mangle, piedras ú otros materiales sumergidos, en lugares de salinidades variables entre 2,91 y 20°/oo, tal como sucede en la Bahía del Tablazo (El Ancón e Islas de Toas y Zapara - Estado Zulia).

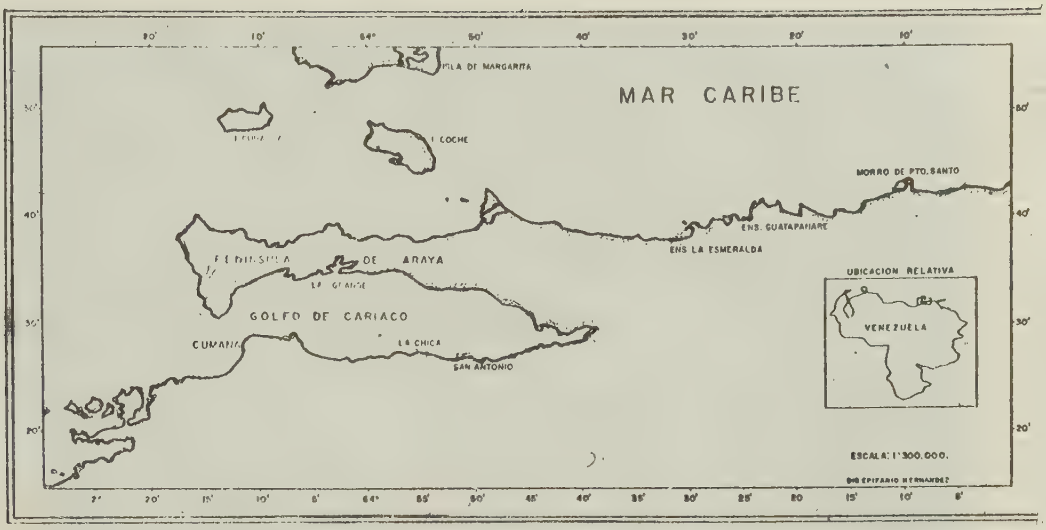
ISLA DE MARGARITA
MAR CARIBE
I. COCHE
MORRO DE PTO. SANTO
ENS. GUATAPANARE
ENS LA ESMERALDA
PENINSULA DE ARAYA
GOLFO DE CARIACO
CUMANA
LA CHICA
SAN ANTONIO
UBICACION RELATIVA
VENEZUELA
ESCALA: 1:300.000.
64°
50'
40'
30'
20'
10'

Fig. 1 Mapa de la Región Oriental de Venezuela (Estado Sucre) mostrando localidades principales en donde existen lechos naturales de mejillón (Enseñada la Esmeralda, Enseñada Guatapanare y Morrô de Puerto Santo)

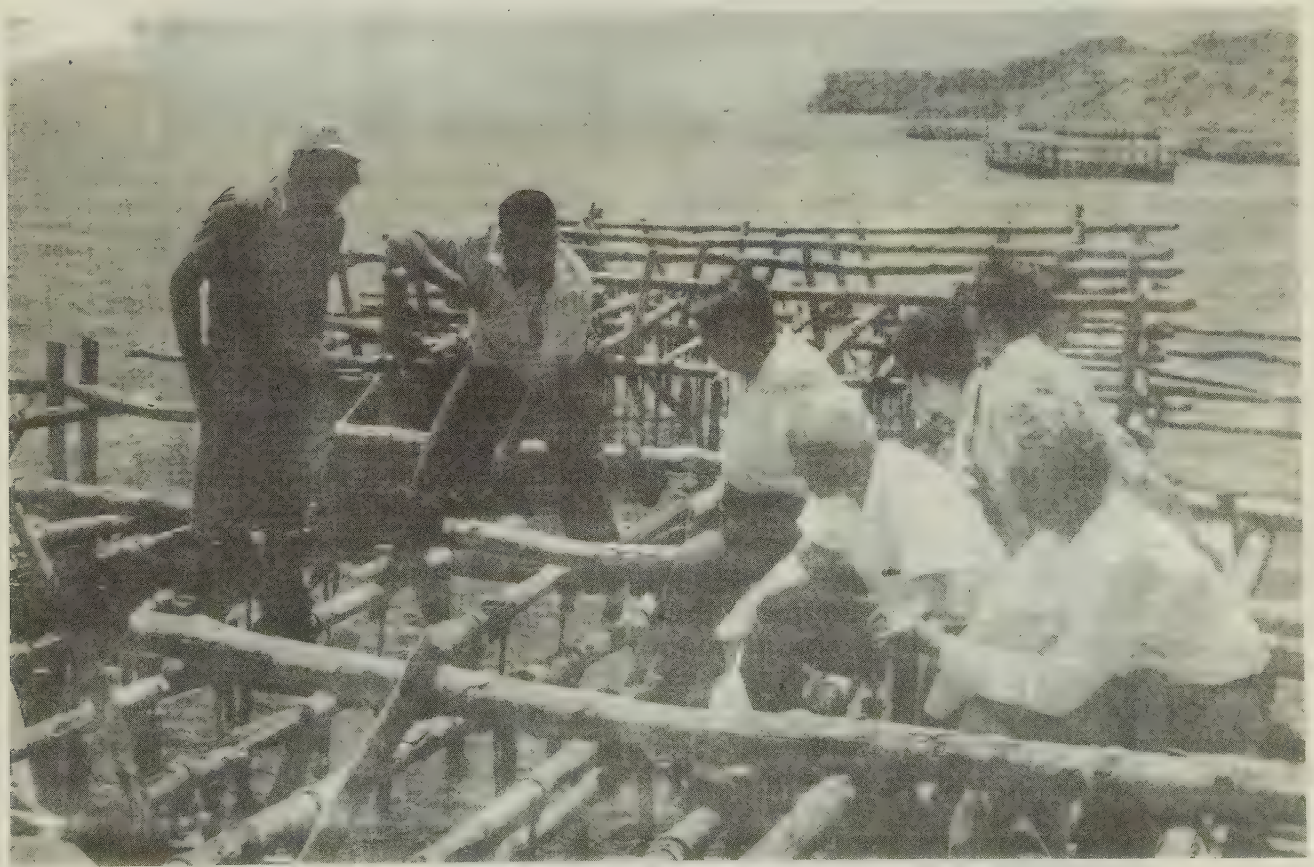

Fig. 2 Detalle de la estructura de la balsa así como de una vara de bambú de 4 m de longitud con mejillón adherido

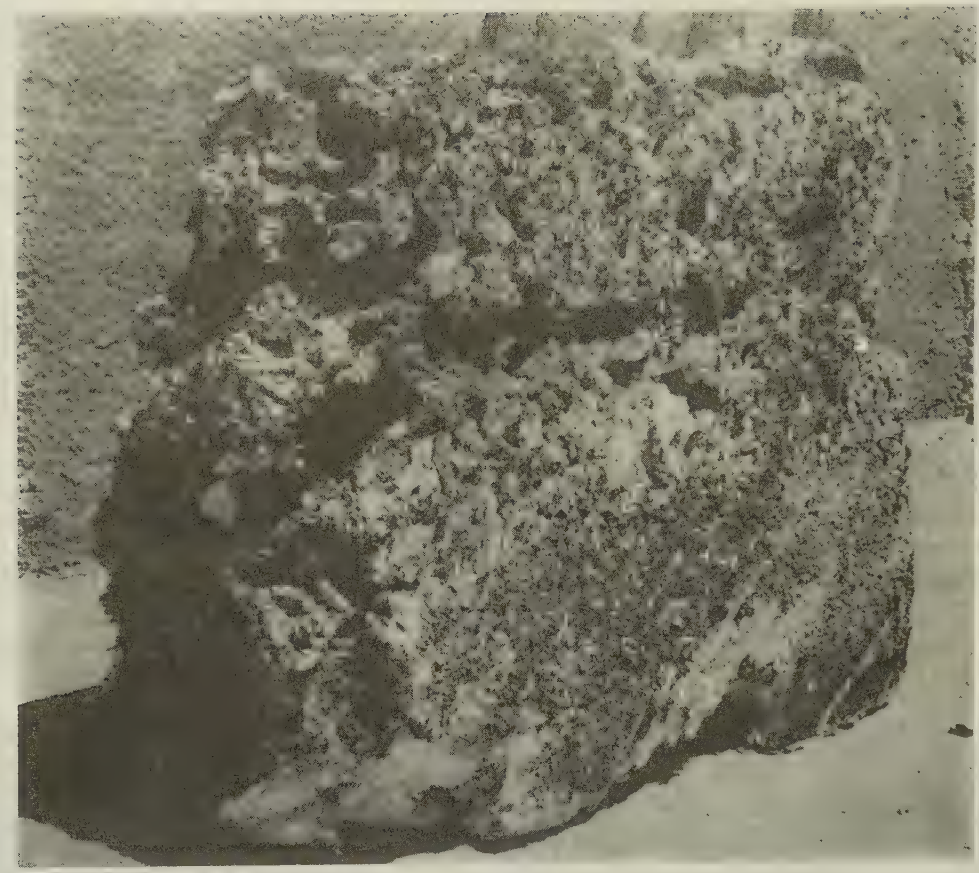

Fig. 3 Flotador de espuma plástica "Styrifoam" parcialmente destruído por la acción de Cangrejos, pertenecientes a las familias Grapsidae, Majidae, Xanthidae y Porcellanidae

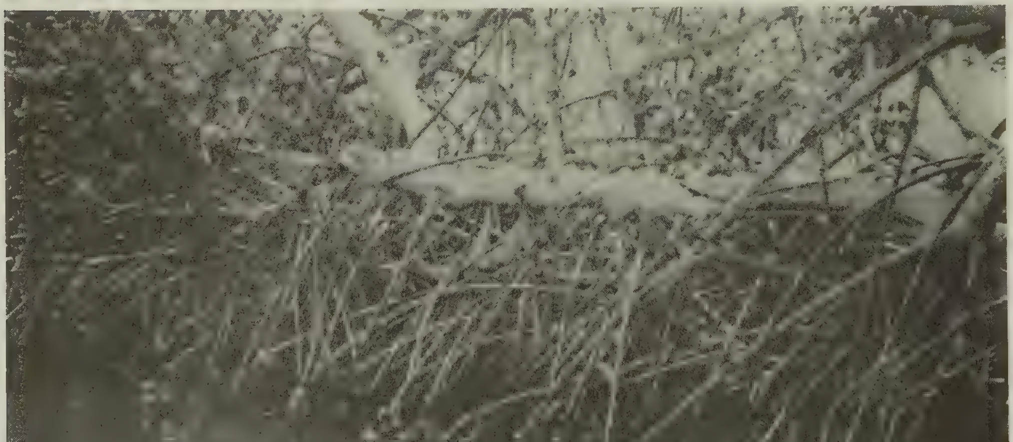

Fig. 4 Raíces aéreas del mangle rojo Rhizophora mangle Linneo, en donde de modo natural se encuentra adherido el ostión Crassostrea rhizophorae (Guilding)

Actualmente se colectan ostiones para el consumo en fresco en varias localidades de la región occidental y centro oriental, tales como las Islas de Toas y Zapara (Estado Zulia), Chichiriviche (Estado Falcón), Higuerote y Totumos (Estado Miranda), Bahía de Mochima y Laguna Grande del Obispo (Estado Sucre), y Lagunas de la Restinga, Las Maritas (Nueva Esparta). La Laguna de Patanemo (Estado Carabobo) hace años muy productiva en este renglón, ha sido depauperada hasta el extremo de que es materialmente imposible encontrar ostiones en dicha laguna.

En 1962, debido al potencial de semilla "spat" que se perdía y al aumento considerable del consumo (167 toneladas en 1965, 861 en 1966 y 96 en 1967) basado exclusivamente en la recolección indiscriminada del recurso (Fig. 5) el Instituto Oceanográfico de la Universidad de Oriente dió comienzo a experiencias preliminares que sirvieran de base a una industria ostrícola que pudiera garantizar de modo permanente la explotación de este perseguido recurso. En tal sentido Mosqueira (1941) efectuó los primeros intentos de cultivo y Martínez (1961) hizo las primeras observaciones sobre la bioecología. Andreu inició en 1962 las observaciones sobre crecimiento bajo condiciones de inmersión continua, elaborando y recomendando un plan a seguirse. Okuda y colaboradores efectuaron de 1965 a 1967 (Bonilla et al. 1967) estudios comparativos sobre la influencia de factores ambientales en diversas localidades del oriente del país. Bonilla y Benítez (1968) investigaron el engorde bajo condiciones naturales y de cultivo experimental en la Bahía de Mochima. Por otro lado, la preocupación del Ministerio de Agricultura y Cría en la conservación de los recursos naturales, llevó a su Centro de Investigaciones Pesqueras en 1964 a ensayar diferentes materiales como posibles colectores de semilla, lográndose resultados muy satisfactorios, principalmente con madera y tejas encaladas (3 partes de cal, 1 parte de arena, 1/4 parte de cemento) (Figs. 6 y 7) cajas de huevos, varas de guatacare y conchas viejas del mismo animal. Con el bambú, aúnque se obtuvieron excelentes resultados, se presentó el problema de su destrucción debido al ataque de perforadores, principalmente por miembros de la superfamilia Adesmacea (Bankia y Teredo).

En vista de las numerosas experiencias realizadas y los resultados positivos obtenidos (Fig. 7) creemos que es factible en Venezuela el cultivo de ostiones por medio de balsas en las localidades del oriente sometidas a observaciones, faltando solo el estudio en pro de un diseño económico y duradero de una balsa y sistema de flotadores en donde colocar los soportes o colectores.

En tal sentido se ha ensayado con éxito parcial una balsa sumamente económica (Fig. 8) con flotadores construídos con bidones de aceite, previamente recubiertos con pintura anticorrosiva y posteriormente con una capa de concreto impermeabilizado. Se ha pensado en la posibilidad - siempre y cuando resulte económica - de llenar los bidones que han de servir de flotadores con espuma plástica "Styrofoam". Con esta solución se logra la insumergibilidad de los flotadores a la vez que se protege al "Styrofoam" de la acción destructora de cangrejos y otros organismos socavadores.

4 OSTRA PERLIFERA: Pinctada imbricata (Roding)

Según los conocimientos de que disponemos actualmente se encuentra formando placeres en varios lugares a lo largo de la costa nor-oriental de Venezuela, siendo especialmente abundante alrededor de las Islas de Margarita, Coche y Cubagua (Fig. 9).

En los últimos años su explotación ha dejado de ser una actividad fundamental en las islas anteriormente mencionadas debido: (1) al bajo valor de la perla en el mercado; (2) el agotamiento de los lechos naturales (Cuadro II).

La explotación de la ostra perlífera está regulada por la "Ley de Pesca de Perlas" y la temporada de explotación se inicia cada dos años, efectuándose la extracción durante los primeros meses de la temporada autorizada. En la actualidad existe la tendencia cada vez mayor de utilizar este recurso para fines de conserva, y a pesar de las grandes posibilidades económicas que presenta este lamelibranquio, son muy pocos los que en Venezuela han trabajado sobre su biología y ecología. Manzo hizo en 1943 observaciones sobre el desove y Galtsoff (1948) presentó un informe al Gobierno Nacional recomendando un plan general a desarrollarse en un plazo de cinco años. Martínez (1967) describió la larva Veliconcha y el juvenil Dissoconcha. Desgraciadamente hasta la fecha es muy poco lo que se ha hecho. Datos biológicos de gran importancia referentes a la madurez, proporción de sexos, época e intensidad de los desoves, fijación de juveniles y tasa de crecimiento continúan siendo desconocidos.

CUADRO II

Producción de Perlas por temporadas a partir del año 1937

AÑOS	KILATES	BOLIVARES	SACOS
1937	418 207	481 181	
1940	1 369 874	879 172	
1943	4 998 257	2 368 656	
1945	1 400 214	1 050 160	
1946	1 281 899	1 666 468	
1947	1 784 857	4 164 910	
1948	1 318 042	2 416 213	
1951	941 604	1 196 354	
1953	978 391	1 314 692	
1955	586 884	759 539	
1957	442 198	1 102 680	105 480
1959	4 321	5 401	51 385
1961	239 622	382 917	103 599
1964	52 555	68 321	
1966	30 046	39 000	

Fuente: M.A.C. Dirección de Recursos Naturales Renovables
División de FAUNA

Fig. 5 Fotografía mostrando destrozos debidos a la extracción irracional del ostión

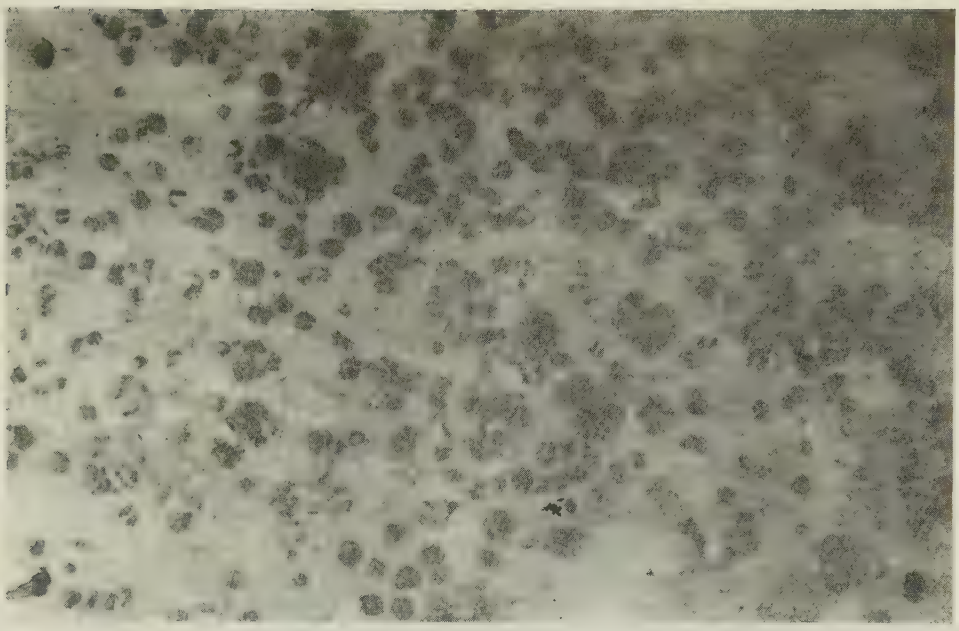

Fig. 6 Fotografía de colector artificial a base de madera de pino encalada, materialmente cubierto de Semilla "Spat"

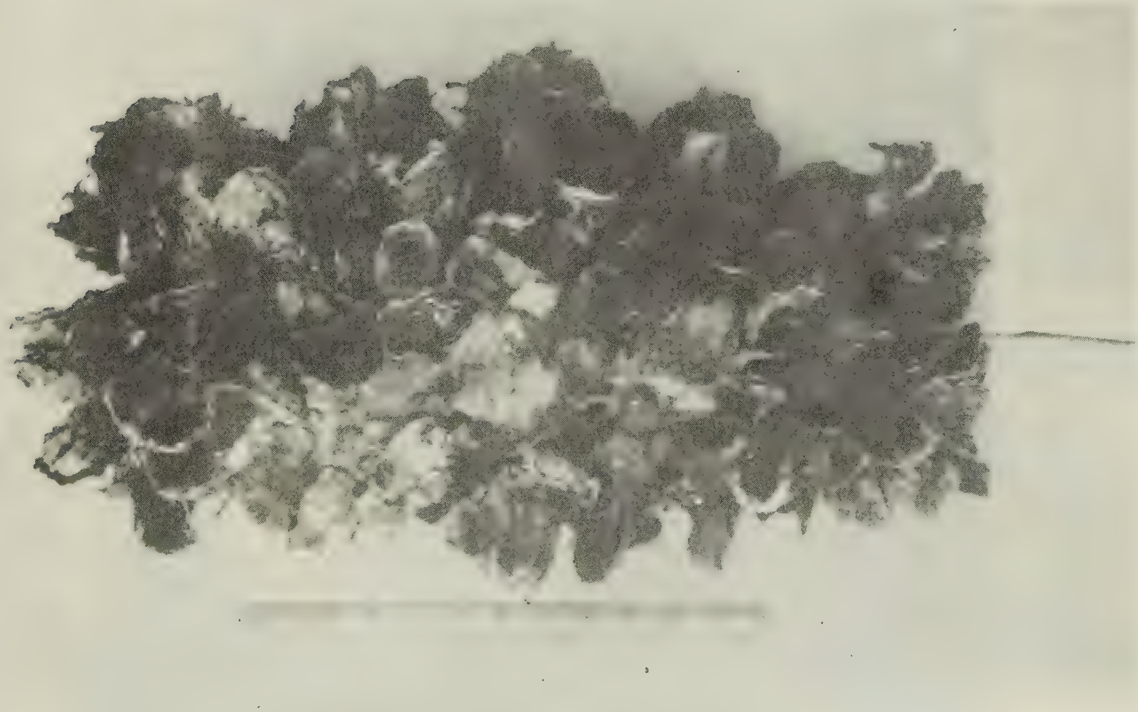

Fig. 7 Teja encalada empleada como colector artificial, mostrando el resultado obtenido despues de 5 meses de inmersión continua, suspendida de un balsa experimental fondeada en la Laguna Grande del Obispo (Golfo de Cariaco)

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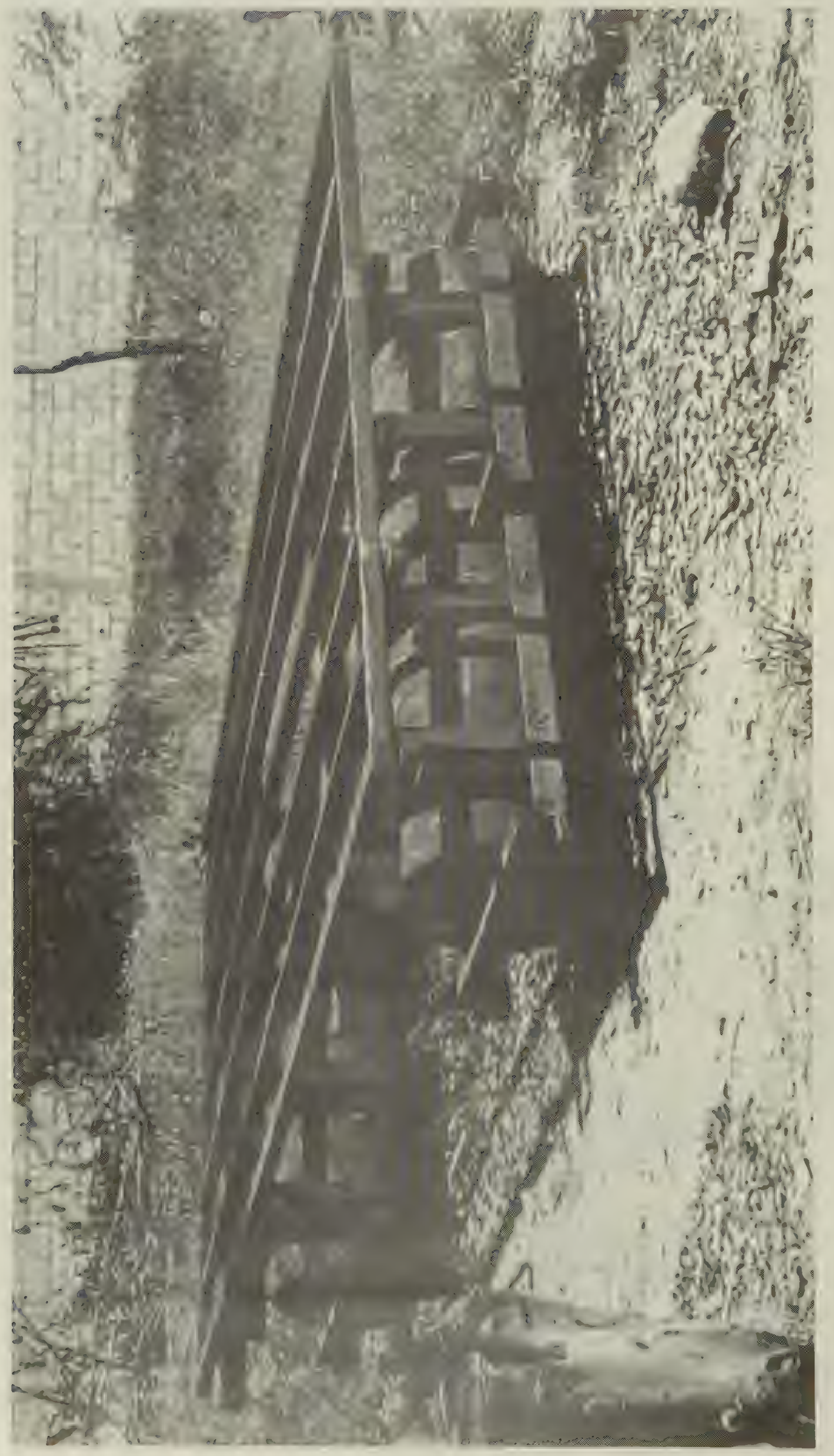

Fig. 8 Balsa experimental de 4 x 4 m, con estructura de madera y flotadores a base de bidones de aceite de desecho recubiertos con concreto impermeabilizado

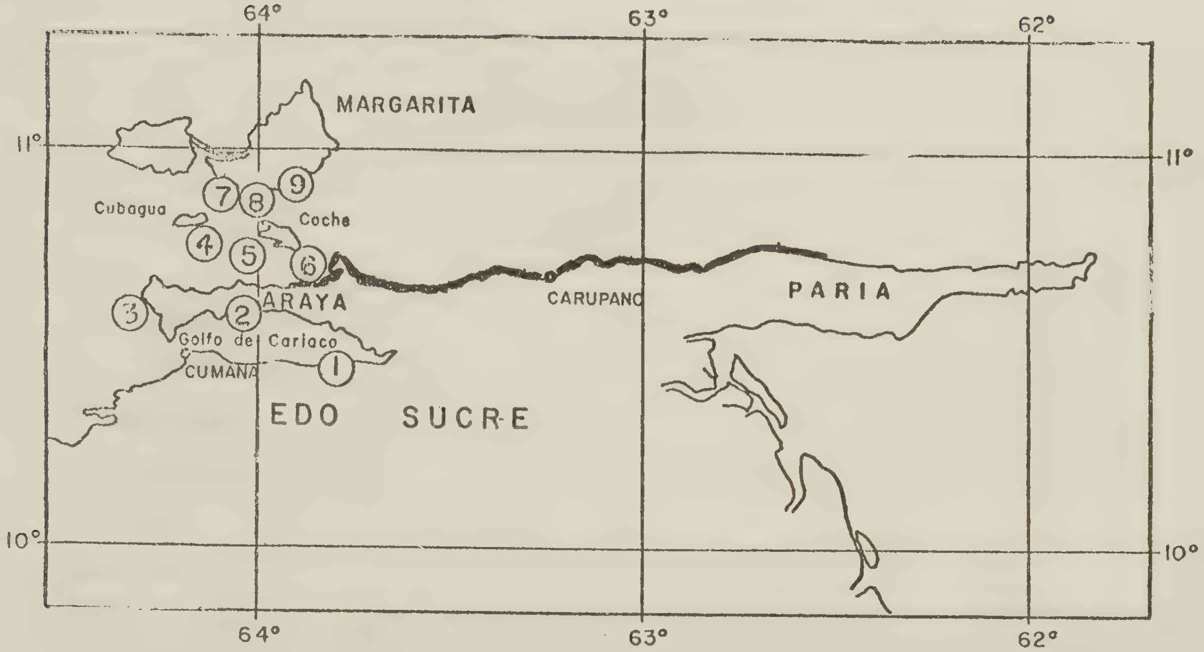

Fig. 9 Mapa de la Región nor-oriental, mostrando con los círculos numerados 4, 5, 7 y 8 los principales placeres de ostras perlífera, existentes alrededor de las Islas de Margarita, Coche y Cubagua

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POSSIBILITIES OF MOLLUSCAN CULTIVATION IN THE CARIBBEAN [1/]

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1 INTRODUCTION

Harvesting of molluscs, especially oysters, for food has been going on for centuries and is worldwide. But much of it can be likened to the hunting and gathering stages which preceded civilization. In some technically advanced nations, the techniques have reached a stage analagous to range or forestry management. Some effort is made to improve and manage the crop and to control pests. But primarily the harvest depends on the natural situation and is at the mercy of the vagaries of nature.

Recently there has been increasing interest in farming the sea, partly from a desire for greater profit, and partly from the need to alleviate a growing protein deficit in the world food supply. Species of molluscs are acceptable as food to many peoples, and they are highly nutritious. Most of the commercial species are herbivorous and hence near the base of the food chain. They harvest the wild marine plants and convert them to usable animal protein. And they are more amenable to manipulation by man than most other types of edible marine animals.

In many respects molluscs are more like crop plants than like domesticated animals, since they are sedentary during most of their lives and can be planted and harvested similarly to land crops. The techniques of modern agriculture are therefore more immediately applicable to them than are those of animal husbandry.

Agriculture began when primitive man saved seed for the following year's planting and developed methods to control weeds, competitors, and various other pests. Later development included selection of better yielding strains, fertilization and finally intensive mechanization along with scientific breeding, including hybridization, selective use of pesticides, and other more sophisticated methods of control.

In some instances, the marine farmer has actually adopted some of the methods of modern agriculture, including controlled production of "seed", rearing under controlled conditions, and even selection and hybridization of strains, although the latter is still in its infancy. Such application of techniques has been called mariculture.

The most advanced mariculture is now practiced in Japan, where hatchery-spawned shrimp are reared under controlled conditions in ponds and tanks. Even in Japan, oyster farming is not so advanced. However, hatchery-spawned oysters are allowed to attach to long strings of cultch material. The strings are then suspended vertically from rafts in open water. The oysters are thus able to utilize food from the entire vertical water column, and predation by benthic organisms is forestalled. This method allows for some mechanization in handling the crop.

[1/] Contrib. No. 229, Department of Oceanography, Florida State University. Research on cytotaxonomy of clams and oysters was supported by National Science Foundation Grant No. GB-5034.

In some countries where labour is expensive, planting and harvesting of bottom-grown oysters has also been mechanized to a considerable degree.

I propose here to describe some of the possibilities that exist for upgrading the production of edible molluscs, not only in the Caribbean, but elsewhere as well. Suggestions for molluscan cultivation in the Caribbean will be based primarily on my observations on clams and oysters in the northern Gulf of Mexico. At the end, I shall speculate on the possibility of cultivating gastropods.

I shall not attempt to document each statement. A selected bibliography of general and specific references is appended. It is neither complete nor exhaustive, but it should serve as an introduction to the literature for those interested in further research in molluscan mariculture.

2 DISCUSSION

Successful farming of molluscs, like successful agriculture, involves certain prerequisites. Suitable growing areas require accessibility, protection from storm damage, proper type of bottom, abundant food of the proper kind, no adverse temperature or salinity gradients, etc. Because of the custom of eating uncooked molluscs, the area should be free of domestic pollution. There also should be no industrial pollution; industrial effluents have repeatedly destroyed or curtailed oyster production in formerly successful areas.

Agriculture has advanced in many areas through the addition of plant nutrients of the proper types and quantities. Aquaculture, the farming of fresh water, has also successfully used fertilizers to increase plant life and hence increase the other forage organisms for the fish that are being reared. Several factors militate against the fertilization of marine habitats. It is impractical because of the dilution factor, except under certain controlled conditions, e.g. ponds and tanks. Also the marine environment is a very complicated ecological situation and we do not now understand all the ramifications that would result, especially during the rearing of filter-feeding molluscs, many of which are very selective in the food they eat.

An example illustrates the problems that fertilization may cause. The wastes from a large duck-raising industry in Long Island, New York, fertilized an oyster growing area. No excessive mortality occurred in the oysters, but they remained in very poor condition, although analysis of the water showed the phytoplankton to be very abundant. Further investigations showed that the dominant species of phytoplankton were types unacceptable as food by the oysters. This is an example of "starving to death in a sea of plenty".

The control of pests, including diseases, parasites, predators and competitors, has long been a problem for man when attempts were made to cultivate a species. The disproportionate increase of one species upsets the balance. Such conditions result in more rapid transmission of diseases and parasites because of the increased density and closer proximity of hosts; in population explosions of predators because of the increased food supply; and in the case of oyster culture, in additional substrate for the attachment of larval forms of the epifauna. The end result is sometimes disastrous. The agriculturists are more successful in the control of pests than the cultivator of marine organism, partly because more effort has been made to find effective controls, and partly because the terrestrial environment is easier to manage than the aquatic one. However, the outlook is far from hopeless.

For instance, a disease caused by a parasitic fungus, Dermocystidium marinum Mackin, Owen and Collier, is estimated to kill yearly up to 50 percent of the adult oysters in some areas along the Gulf of Mexico and lower Atlantic coasts of the United States. Young oysters are highly refractory to the pathogen and the mortality in adult oysters is limited to the warmer season. No method for control of the disease organisms themselves has been found, but a change in management, resulted in effective control. The oyster growers in one large productive area now harvest their crop earlier, before the disease has caused extensive damage, even though the oysters have not reached maximum size.

Dermocystidium marinum is probably endemic in the Caribbean area and could be a serious deterrent to the establishment of an oyster industry, especially since the continual warm water would favour the parasite.

A disease caused by a sporozoan parasite, Minchinia nelsoni Haskin, Stauber and Mackin, called "MSX" before the causative agent was classified, caused up to 95 percent mortality of oysters in parts of Delaware and Chesapeake Bays on the Atlantic coast of the United States. Efforts to develop a strain of oysters genetically resistant to the disease have been unsuccessful to date. However, acquired immunity has been demonstrated. Oysters that have set and grown in endemic "MSX" areas have less mortality among the larger animals than imported seed oysters from areas where the disease does not occur.

The terrestrial farmer gets rid of weeds by cultivation, and in recent years by the judicious application of pesticides. The marine farmer can also cultivate; one method is to dredge an oyster bed with an open-bag dredge, which turns over the shell and exposes clean surfaces for the oysters to attach to. Methods have been developed to "plow-under" or bury certain pests. Pesticides have also been used experimentally, sometimes successfully. Certain predacious gastropods are effectively controlled with application of Ortho-di-chloro-benzene and "Sevin" (1-napthyl-N-methyl-carbamate). Certain pesticides are very effective in controlling species of Crustacea that are injurious to oysters. Calcium oxide (quicklime) is effective in controlling sea-stars. The quicklime which is relatively insoluble, is spread over infested oyster beds. When it comes in contact with the sea-star body, it causes lesions and death. In Australia, a species of mudworm bores into the oyster shell and causes extensive damage. To control this pest, wooden racks are built off the bottom for the oysters to attach to and grow.

The use of chemicals in pest control is sometimes hazardous, even in terrestrial farming. In the marine environment, where there are complicated ecological relationships between many organisms, caution is imperative. For example DDT, as well as other pesticides, will prevent the attachment of barnacles, a serious competitor to oysters, but is also toxic to oyster larvae. Certain pesticides will control or kill crustaceans that are predators of clams and oysters but they will also kill valuable commercial species of shrimp, lobster and crabs.

If extensive molluscan cultivation is established in the Caribbean area there is every likelihood that there will be problems with injurious organisms, and suitable methods for their control will have to be developed. Fundamental to all controls of harmful biotic agents is basic research on the organisms involved. Control techniques are imperative in cultivation because of the investment involved. In addition, control of pests would increase the supply of the native species that are now harvested.

The necessity for a supply of healthy "seed" is as fundamental to mariculture as it is to agriculture, and this ultimately requires something more reliable than the natural crop of young organisms. The fundamental requirements for large scale molluscan hatcheries have only recently been determined. The next decade should see a geometrical increase in hatcheries as methods improve and the commercial as well as the scientific benefits are realized. At present, large hatcheries beyond the experimental scale, are existent only in Canada, Japan, the United States and some Western European countries. Hatcheries are utilized more in Japan, at least on a commercial basis, than elsewhere, with well established techniques for molluscs, such as abalones, oysters and scallops. With modifications, most mollusc species can be hatchery-reared. Hatchery rearing, when perfected, is economical in that millions of offspring can be reared from very few parents.

Essentially what is needed for clam and oyster hatcheries is a salt water supply flowing through a non-toxic system, containing food, but no substances harmful to the developing larvae. Some hatcheries utilize the naturally occurring food in the sea water, after removing the larger zooplankton by sieving or centrifuging. Although this method has proven satisfactory, the number of larvae that can be reared in a given space is less than if specific cultured algal food is added, either as supplemental feeding or as the entire food supply. The culture of "food" species of algae requires the addition of proper nutrients and, in the case of some species, a constant temperature and light source.

The larvae can be reared in aerated, cone-shaped tanks of several thousand litre capacity. (On an experimental basis, I use larval culture tanks of only 20 litre capacity.) The water is changed daily or every other day, by sieving the larvae through screens of proper size. Sieving the larvae and adding new water prevents the accumulation of toxic metabolites and hence reduces mortality. With the addition of new water, an antibiotic to control bacterial contamination is added along with the food.

Sexually mature pelecypods can be induced to spawn by a combination of heat shock and introduction of a sperm suspension from a sacrificed male. In our laboratory we have obtained the best results with clam and oysters by alternately heating the water to about 30°C and cooling it to 20°C. We have a continuous supply of heated and refrigerated sea water. In the Caribbean it probably would not be necessary to heat the water but there should be a method to cool it. Refrigerated sea water is also needed to store sexually mature molluscs at temperatures below the minimum threshold for spawning until they are to be used.

We have obtained the best results with clams in the early spring, when rising sea water temperatures have induced gonadal development, but before natural spawning occurred. Clams can be conditioned to produce mature gametes during the winter, by subjecting them to elevated temperatures in the laboratory. We have never had success in spawning clams after rising temperatures have induced spawning in nature. We have been able to induce some oysters to spawn throughout the warmer period (about ten months of the year) by a combination of temperature shock and sperm suspension addition. In colder regions oysters, like clams, can be conditioned to sexual maturity during the winter.

Oysters in the genus *Crassostrea* can be "stripped", i.e. a suspension of gametes can be removed from sacrificed male and female animals. When mixed together fertilization of the ova by the sperm occurs readily. We have obtained fertilization from a few other species of pelecypods by stripping both sexes, but in clams, as in most of the pelecypods, ova must be obtained by natural spawning in order for fertilization to occur. Stripped sperm are functional in all the species we have observed. Each female produces millions of eggs and if all were reared, one female parent would supply enough seed to plant upward of a hectare. Hence only a few parents are needed.

After the ova are fertilized they are sieved to remove extraneous material and placed in larval rearing tanks. Feeding commences on the second day after the larvae have utilized all of the stored food and have developed into the gastrula stage. Normally, depending on the food supply and the temperature, in clams and oysters, metamorphosis occurs within two weeks. Under optimum conditions faster growing larvae go through metamorphosis in 9 to 10 days, but we have observed metamorphosis as late as three weeks. Temperatures that are too low slow development, whereas temperatures that are too high promote excessive bacterial and fungal growth. We have obtained the best results at temperatures of about 25°C for clams and 28°C for oysters. Recent investigations indicate that oyster larvae feed on progressively larger phytoplankton as they mature. Thus it would be advisable to introduce progressively larger species of phytoplankton into the culture tanks as the larvae grow. There is a continual attrition of the larval population especially when the larvae are sieved with the water changes, and therefore, the more rapidly the larvae develop, the better the yield.

Clams become benthonic upon metamorphosis and are removed to trays or aquaria, with or without flowing water. If flowing water is used the normally occurring phytoplankton serves as a food source but supplemental feeding with cultured algae enhances the growth rate. Oysters attach to a substrate, called cultch, upon metamorphosis. Various types of cultch, usually shells of oysters or other pelecypods, are placed in the tanks when the larvae reach the stage of attachment. After attachment they are handled much as clams are. Recently a commercial hatchery has developed a technique to produce so-called "cultch-less" oysters, that is individual, unattached seed oysters. It is claimed that these seed oysters, called spat, have certain advantages, among them their ability to develop into better shaped oysters coupled with a reduction of the bulky cultch material.

Additional details on hatcheries can be found in the reference materials, especially those from the U.S. Bureau of Commercial Fisheries Biological Laboratory, Milford, Connecticut, where most of the techniques were developed.

One of the most exciting and rewarding possibilities inherent in shellfish hatcheries is that of truly "domesticating" the molluscs. It is through hatcheries that selection of improved strains can be accomplished. Because only a few parents are needed, the pedigree of these can be known, and rigorous selection can be practised which should result in rapid fixation of desirable traits. One commercial hatchery is selecting oysters for faster larval growth and earlier metamorphosis by the simple procedure of retaining only the largest larvae each time they are sieved with the water change. A logical extension of this procedure would be to use only the faster growing and larger oysters, reared from hatchery stock, for parents for future hatching. Most of the cultivated plants and domesticated terrestrial animals were developed long before the science of genetics was known. With our present knowledge we should be able from the outset to apply modern methods such as introduction of better foreign species, in-breeding, hybridization, selection for disease resistance, etc., to the development of greatly improved molluscan stocks.

For the past several years I have been studying the taxonomic, cytological, and genetic relationships of two species of clams of the genus *Mercenaria*, and of as many species of oysters in the genus *Crassostrea* as I could obtain. I would like to speak now of the possible applications of some of this work to clam and oyster mariculture.

Clams

Two species of quahog clams occur along the Atlantic and Gulf coasts of North America. The northern quahog, *Mercenaria* (*Venus*) *mercenaria* L., occurs from the Gulf of St. Lawrence southward to Florida and along the northern coast of the Gulf of Mexico. It is represented by a subspecies along the southern half of the Florida Atlantic coast and the northern Gulf of Mexico. The southern species, *M. campechiensis* (*Gmelin*), is found from the New Jersey coast southward to Florida and in the Gulf of Mexico. It is reported from Cuba and probably occurs in other areas of the Caribbean.

The two species differ physiologically as well as morphologically. The northern species has the ability to remain tightly closed and alive for long periods when removed from the water, whereas the southern form quickly gapes and dies. The southern clams have a greater annual growth than the northern clams and also different seasonal growth when planted in the semi-tropical waters of northwest Florida.

The commercial fishery is based largely on the northern quahog and on small clams from 50 to 75 mm long, used in the half-shell trade. Large clams, which are tough, are used in chowders, etc., but must compete with the more efficiently harvested and abundant ocean quahog and surf clams. Besides the gaping and spoilage of the southern quahog, when removed from the water, there are several other reasons for the relatively small fishery for this species. Some areas, where it occurs in abundance, are condemned because of pollution. Clam fishing is not progressive in the southern states because of the lack of fishery knowledge on the part of the fishermen, the lack of market and also competition from the well established and profitable fisheries for shrimp, crabs, spiny lobsters and mullets.

To establish an experimental clam farm, we planted small northern quahogs in the size range from 10 to 25 mm, obtained as culls from a commercial fishery. They were planted at various concentrations in fenced plots ranging from 125 to 250 square metres. Protective fences effectively prevented predation; mortality was usually less than 10 percent. Unprotected control plantings had 100 percent mortality, usually within two weeks, chiefly from predation by crabs and gastropods (Busycon sp.). Starting with clams of this size, it was found that over 250 clams per square metre would attain market size for the half-shell trade in a little over a year.

For the past several years we have been making observations on laboratory spawned northern and southern quahogs and their F_1 and F_2 hybrids. Figure 1 and Table I show the growth of the four groups planted under the same conditions, Figure 2 shows the shell increase at bi-monthly intervals. The observations on the two parent species and the F_1 hybrid were made concurrently; however, the data for the F_2 hybrids were taken two years later and there are seasonal differences in the growth. The following generalizations hold true. All of the clams had the greatest shell increase during the spring and fall periods. All of the groups showed some shell increase during the winter period, but the northern species had better growth during this colder period than did the southern species. During the warmest period in the summer, shell increase slowed in the northern quahog, whereas the southern grew almost as much as in the faster growing spring and fall periods. The southern species, whose parents were native to the area, had greater annual growth than did the northern species which were native to a higher latitude. Shell growth of the hybrids resembled that of the southern parent more closely than that of the northern and, in fact, the F_1 hybrid surpassed the southern parent in shell growth after several years.

That the two species hybridize readily in the laboratory has been known for some time and the F_1 hybrids are fertile. They are sympatric in part of their ranges, and I think that hybridization is occurring in nature as well. There is little likelihood that this is true in the northern part of the region where their ranges overlap, because the two species are separated ecologically. M. mercenaria is found in bays and inlets, whereas M. campechiensis only occurs offshore in the shallow neritic waters. Beginning about half way down the Atlantic coast of Florida, however, the two species grow in juxtaposition and opportunities for hybridization should be plentiful. That hybridization actually occurs is suggested by the fact that the subspecies of M. mercenaria, which is the most common representative of the northern species in the area where the two species grow juxtaposed, closely resembles laboratory-spawned F_2 hybrids between the two species.

Observations were made on laboratory spawned and reared (in our area) M. mercenaria, M. campechiensis and their F_1 hybrid as to their ability to remain closed when removed from the water. All of the clams were in the size range from 60 to 70 mm and were kept under refrigeration at 3-5°C. The majority of the southern species started gaping within 24 hours and all were either gaping or dead in 60 hours. All the northern species were living and mostly in good condition after 350 hours (over two weeks), when the observations were terminated. Less than 20 percent of the F_1 hybrids were gaping at the end of 350 hours. The physiological condition of the clams will determine, partly, the storage duration out of water, as well as the temperature of storage. A moist cool atmosphere is more conducive to long storage than a warm dry one. After the clams have spawned and are in an emaciated condition, even the northern species will gape within a week or less, even under refrigeration.

Our observations indicate that hatchery-reared hybrids between the two species might be the best thing to plant in clam farms. The hybrids are easy to produce and rear. They have the adaptability of the southern parent to tropical waters, a good growth rate, and the good out-of-water storage qualities of the northern parent. Satisfactory techniques for large scale rearing of large numbers of clams from time of metamorphosis until they reach a size large enough that they can be planted safely in fenced areas, have not yet been developed. Clams as small as 1-3 mm can be planted if they are given extra protection, but it entails considerable labour.

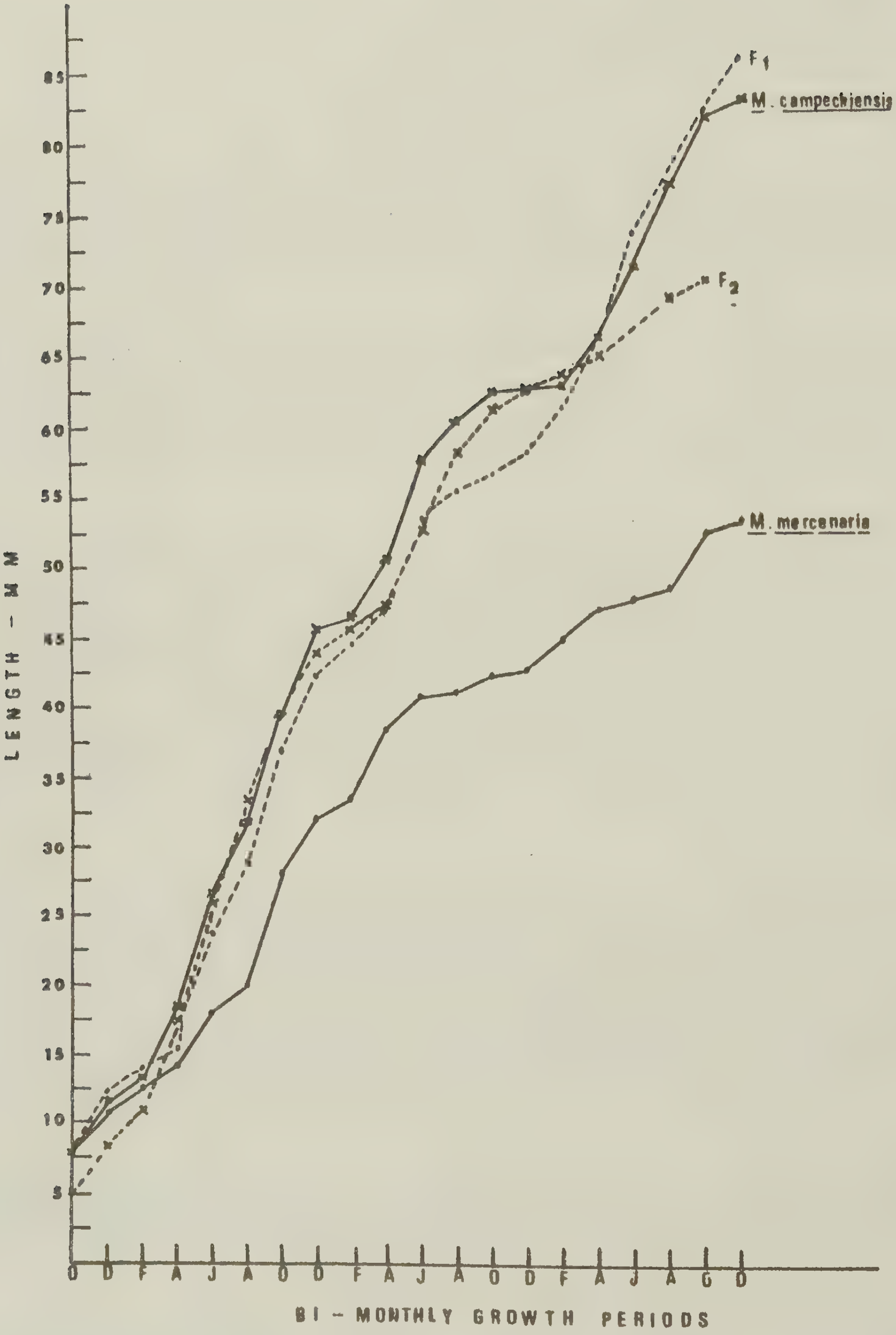

Fig. 1 Growth of Mercenaria mercenaria, M. campechiensis and their F_1 and F_2 hybrids

TABLE I

Sizes of *Mercenaria mercenaria*, *M. campechiensis* and their F_1 and F_2 Hybrids at Bi-Monthly Intervals

Month	*M. mercenaria* No.	*M. mercenaria* Length (mm)	*M. campechiensis* No.	*M. campechiensis* Length (mm)	F_1 Hybrid No.	F_1 Hybrid Length (mm)	F_2 Hybrid No.	F_2 Hybrid Length (mm)
Oct.	50	8.0	50	8.0	100	8.0	150	5.0
Dec.	50	10.0	50	11.4	93	12.2	118	8.3
Feb.	49	12.5	49	13.2	93	14.0	102	11.9
Apr.	49	14.0	49	18.4	93	15.4	101	17.5
Jun.	47	18.2	48	26.6	92	23.8	98	26.0
Aug.	46	20.0	48	31.8	91	28.4	92	33.4
Oct.	43	28.2	48	39.6	90	36.8	88	38.3
Dec.	43	32.1	48	45.6	90	42.3	87	43.8
Feb.	42	33.5	48	46.7	90	44.4	87	45.7
Apr.	41	38.7	45	50.5	90	46.7	86	47.4
Jun.	40	40.8	45	57.4	90	53.3	86	52.5
Aug.	39	41.1	45	60.3	89	55.4	84	57.9
Oct.	39	42.2	45	62.3	87	56.5	83	61.0
Dec.	38	42.6	45	62.5	87	58.1	81	62.3
Feb.	38	44.9	43	62.7	87	59.2	81	63.5
Apr.	38	47.0	43	66.9	86	65.5	81	64.8
Jun.	38	50.1	42	76.3	82	73.5	81	66.4
Aug.	37	51.7	41	79.8	81	77.0	81	67.6
Oct.	37	52.7	41	81.8	81	82.9	81	68.5
Dec.	37	53.1	41	82.6	81	85.7	-	-

Note: Measurements to nearest 0.5 mm on or near fifteenth of month.

The success of clam mariculture in the Caribbean is speculative. Unforeseen difficulties would undoubtedly arise and it would probably be several years before reliable techniques could be established. One problem that can be anticipated is that clams kept in the tropical waters will spawn more or less continuously, thus mitigating against successful hatchery spawning. If this occurred, clams that are sexually mature but have not spawned could be shipped in from more northern areas. Only a very few parents are needed. Of course clam mariculture is dependent on suitable growing areas, necessary facilities, and some skilled labour.

Oysters

The family Ostreidae contains only three living genera, *Crassostrea*, *Ostrea* and *Pyconodonte*, and of these only the first two are used commercially. Several species of *Ostrea* are cultivated by man, but oysters in this genus are generally smaller than those in *Crassostrea*, and the larger cultivated species are cold water inhabitants. There are three species of *Ostrea* in the Gulf of Mexico - West Indian region but all are small. *Crassostrea* is more euryhaline than *Ostrea* and is more adaptable to a wider range of ecological conditions. Only species of *Crassostrea* are considered for mariculture in the Caribbean.

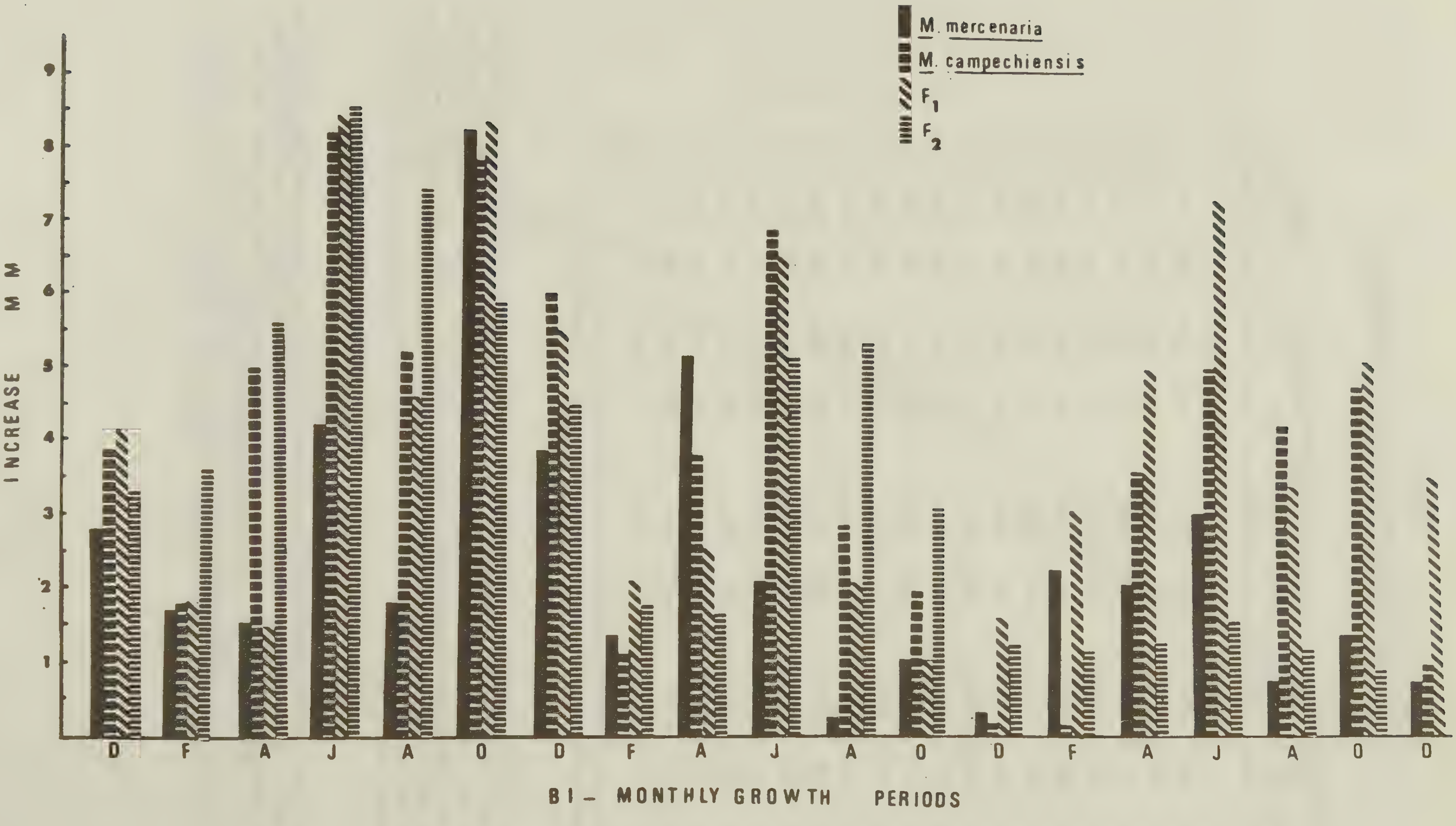

Fig. 2 Bi-monthly increases in sizes of Mercenaria mercenaria, M. campechiensis, and their F_1 and F_2 hybrids

Crassostrea rhizophorae (Guilding), called the mangrove oyster because it is often found attached to mangrove roots, is common to many areas in the Caribbean but the overall fishery is relatively unimportant. The mangrove oyster is a small species, one of the smallest in the genus, and this factor would be against the establishment of a large fishery. There is a possibility, however, that a fishery of some importance could be brought about by the use of proper mariculture techniques. The practices of planting cultch material, protection from pests, determination of the best growing areas and other procedures, would surely enhance the supply of these oysters.

Introduction of an exotic species that already has the physiological adaptation to tropical waters, is of large size and is acceptable to the consumer, would seem to be a good possibility for the establishment of an oyster fishery in the Caribbean area. (The oyster industry of the Pacific North American coast is based on an introduced species.) Caution should be taken that the proper species is introduced under carefully controlled conditions. The ecological requirements of the species to be introduced should be determined as well as the possible ecological impact on endemic species. These data should indicate whether or not the species has possibilities for success. Care must be taken that pests, including diseases, parasites, predators and competitors, are not brought in along with the introduction. If an introduction is made, it is recommended that it first be done on a small experimental scale, selecting the best ecological situation, and that constant supervision be exerted over all the parameters.

For the past several years the writer has been investigating the taxonomic, genetic, and cytological relationships of species in the genus *Crassostrea*. Twelve species (including our native species) have been secured from areas of Australia, Brazil, England, India, Japan, Mauritius, Panama Canal Zone, Puerto Rico, Philippines, Singapore and South Africa. Research has included laboratory spawning and rearing of the parent stocks, attempted hybridizations between species, and mitotic and meiotic analyses of the chromosomes of the species and the hybrids. The genus *Crassostrea* can be separated into two groups based on shell morphology and hybridization affinities, one group has denticles along the anterior margins of the shell (typical of *Ostrea*) and a faint pallial line. The other group (which includes *C. rhizophorae*) lacks these two characters. Although species within each group will hybridize with each other in many instances, there is a complete lack of attraction of sperm and eggs between species of the two groups, in all the combinations that have been attempted.

One species from each group seems to have possibilities for introduction into the Caribbean. Both of these species are native to tropical and subtropical areas, are of good size, and are now used commercially. *Crassostrea cucullata* (Born), in the group with shell denticles, is widespread. We have secured it from India, Mauritius, Philippines and Singapore. It showed good shell growth during the warmest period when the water temperature ranged as high as 30-31°C. Those from the Philippines came from an area which had water temperatures of 28-33°C during the period from 6 March to 4 April 1967. Another species from the same area of the Philippines, in fact obtained from the same bed, is *C. iredalei* (Faustino). *C. iredalei* is a larger oyster than *C. cucullata*, and its shell growth, as well as its tissue condition during the warmer periods was considerably better. This species belongs to the group without shell denticles. However, numerous attempts to hybridize it with other species in the group, including *C. rhizophorae*, met with failure. Fertilization and cell cleavage occurred, with some larval development, but no larvae were reared through metamorphosis. Mitosis in the zygotes was anomalous, and haploid, triploid and hexaploid cells were observed.

C. rhizophorae, without shell denticles, crossed readily with several other species in the group including *C. virginica* (Gmelin), the commercial species of the Atlantic and Gulf coasts of North America. Monthly observations on the shell growth of laboratory-spawned and reared *C. rhizophorae*, *C. virginica*, and their F_1 hybrid are given in Figure 3 and Table II. The three groups attached at different times during the summer of 1967; the number of oysters was small, and there was considerable mortality. Hence the growth data are statistically unreliable and not strictly comparable. However, the data do suggest that the hybrid has a growth rate that is better than that of the mangrove oyster and approaches that of the *C. virginica* parent. Mortality was very high in both the hybrid and the mangrove oyster during the winter period when temperatures dropped below 10°C. Earlier attempts to keep imported *C. rhizophorae* always ended in complete mortality during the winter. If low temperature was the factor that caused the mortality, it would not be a problem in the tropical Caribbean. These very preliminary observations do suggest that there is a possibility of establishing an oyster fishery based on hybrids between adapted native oysters and a larger, exotic species.

Gastropods

The writer has no experience with gastropod culture but a survey of the literature suggests that mariculture techniques could be adapted to gastropod cultivation. Two species of gastropods native to the region and presently used for food, the queen conch and the West Indian topshell will be considered.

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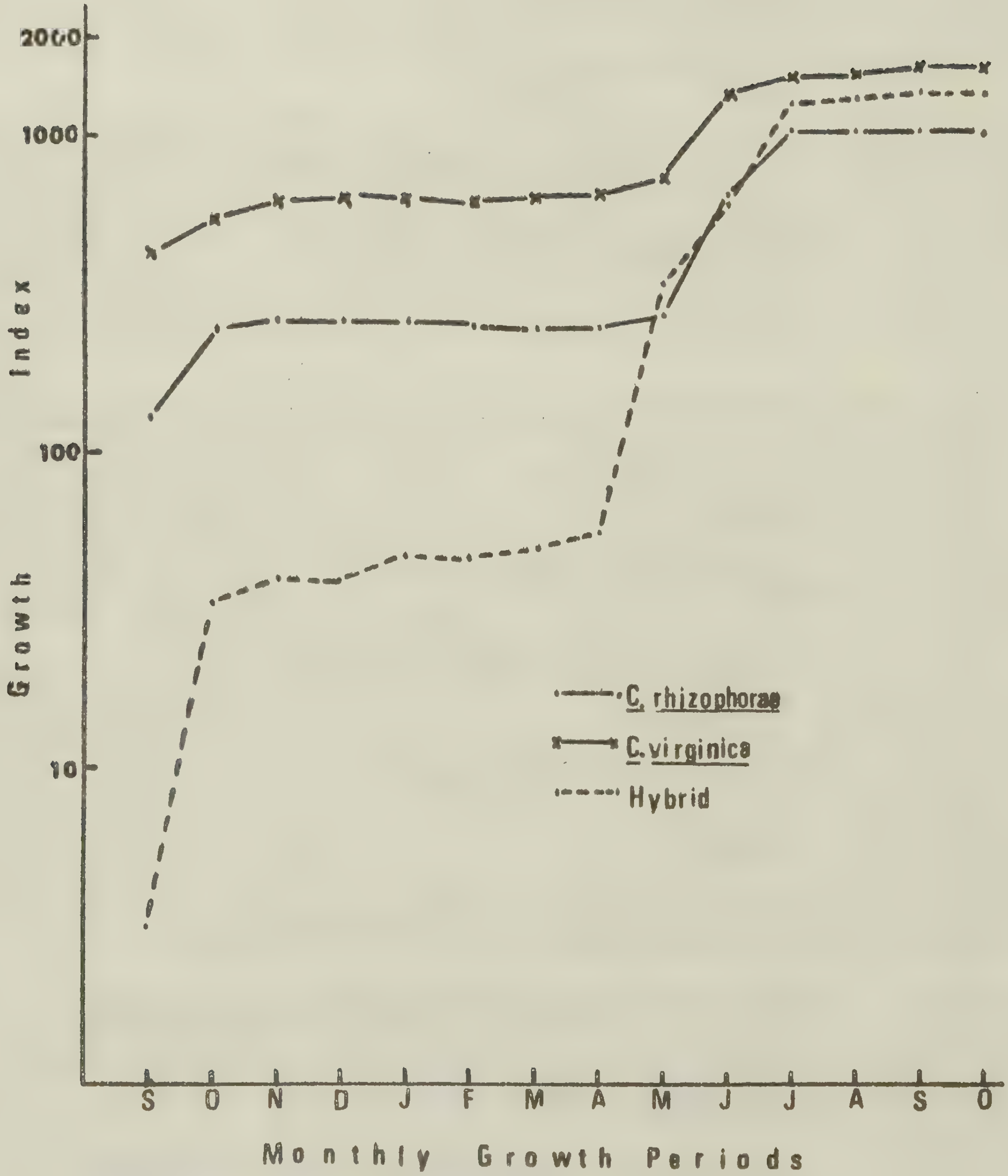

Fig. 3 Sizes of laboratory spawned and reared C. rhyzophorae, C. virginica and their hybrid (growth index is product of length and height)

TABLE II

Sizes of Laboratory Spawned and Reared C. *rhizophorae*, C. *virginica* and their Hybrid

Date* examined	C. rhizophorae No.	C. rhizophorae Lg. x Wd. (mm)	Percent mortality	C. virginica No.	C. virginica Lg. x Wd. (mm)	Percent mortality	Hybrid No.	Hybrid Lg. x Wd. (mm)	Percent mortality	Temperature range (°C)
9/67	34	11.5 x 11.0	-	44	22.0 x 18.5	-	145	2.0 x 1.5	-	22–28
10/67	32	16.0 x 15.0	5.8	44	27.5 x 19.0	0.0	143	6.0 x 5.0	1.4	15–27
11/67	32	17.0 x 16.0	0.0	43	27.5 x 22.0	2.3	142	6.5 x 6.0	1.4	10–18
12/67	32	17.0 x 15.0	0.0	43	27.5 x 22.5	0.0	130	6.5 x 6.0	14.2	2–15
1/68	28	17.0 x 15.0	12.5	41	27.5 x 22.5	4.7	121	7.0 x 6.5	6.9	1–15
2/68	20	17.0 x 14.5	35.7	40	27.5 x 23.0	2.4	111	7.0 x 6.5	9.0	1–13
3/68	18	17.0 x 14.5	10.0	40	27.5 x 23.0	0.0	78	7.0 x 7.0	29.7	5–18
4/68	13	17.0 x 14.5	27.8	40	28.0 x 23.5	0.0	68	7.5 x 7.0	12.8	12–20
5/68	12	18.0 x 15.0	7.7	40	30.0 x 24.0	0.0	58	13.0 x 11.0	14.7	15–22
6/68	10	28.5 x 23.0	16.7	39	40.5 x 30.5	2.5	54	27.5 x 22.0	7.0	20–30
7/68	10	33.0 x 28.0	0.0	36	46.0 x 33.0	7.9	52	39.5 x 32.0	3.7	26–30
8/68	10	35.5 x 28.0	0.0	36	46.0 x 34.0	0.0	52	40.0 x 32.5	0.0	27–30
9/68	10	36.0 x 28.0	0.0	36	47.5 x 34.5	0.0	52	41.0 x 32.0	0.0	27–29
10/68	10	36.5 x 28.5	0.0	36	48.0 x 34.5	0.0	52	41.5 x 33.0	0.0	25–28

* Measurements to nearest 0.5 mm on or near tenth of each month.

4.27

The queen conch, *Strombus gigas* L., is a widely used seafood in many areas of the Caribbean. In certain localities it is second in importance only to the spiny lobster. Not only is the meat eaten, but the shells are used for curios and the manufacture of porcelain.

Queen conchs have an average shell growth of over 50 mm per year, reaching a maximum height of about 300 mm, and a weight of 3 kilograms. Conchs 150 mm and larger are considered of commercial size. There is considerable individual variation in growth rate, and females grow slightly larger than males. Fertilization is internal. The female deposits eggs in a continuous tube that is folded back and forth, forming a mass. The tube may be over 30 metres long and contain over a half million eggs. Egg laying occurs throughout the year except in the more northern part of the range, where it ceases during the colder period. The female may deposit several egg masses during the year.

Queen conchs have been reared in the laboratory on an experimental basis to study the embryology and larval growth. Considerable development occurs in the egg tube before hatching commences on the fifth day. At about the fourth day after hatching the larvae begin feeding, although there is evidence that all the stored food is not utilized until the ninth or tenth day after hatching. In the larvae all adult organs are developed by 21 days, except the gonads, and they approach metamorphosis by 52 days. Metamorphosis is usually complete 60 days after hatching. The larvae have a relatively narrow range of acceptable food organisms, as evidenced by the many undigested species of plankton expelled in the feces. As they approach metamorphosis, they utilized a wide variety of plant species, including attached algae. Many species of macroscopic algae as well as higher plants, including manatee and turtle grass, are eaten by juveniles after metamorphosis and by adults.

Queen conch mariculture does not seem impossible. We know that the conchs can be reared in the laboratory. Additional research would have to be conducted to determine the proper kinds of food for larval rearing in order to establish techniques for successful hatcheries. The larval period before metamorphosis is relatively long compared to that of clams and oysters but perhaps the use of proper foods and the establishment of the optimum in other requirements would hasten development. In hatcheries, selection for faster growth could be practised. After metamorphosis the young should be planted in protected areas. The minimum size at which conchs could be planted would need to be determined.

Planting in fenced areas would be one means of protection from enemies and would allow easier harvesting. In one growth study reported, caged conchs were usually found clustered near the edges of the cages feeding on the algae that had attached to the cage material. The Japanese have long used artificial cultch material to grow desired algae. Suitable cultch material for algae could be placed in the fenced areas to provide a source of food for the conchs. Investigations could determine the carrying capacity of an area in relation to the amount of algae and conchs. It is conceivable that conchs, when they grazed the algae from one pen, could be rotated to another pen, as cattle are rotated on pastures.

The West Indian topshell, *Cittarium pica* L., is widely used for food and is second in importance to the queen conch in some localities. Published data on this species indicate that it would not lend itself readily to mariculture. The growth rate is relatively slow and the maximum size is less than that of the queen conch. An important consideration is that the preferred habitat is rocky shores with wave action which precludes fencing with all its pursuant advantages.

3 SUMMARY

Possibilities exist for culturing molluscs in the Caribbean if suitable, unpolluted growing areas with all the ecological requirements are available. Considerable labour, some of it skilled, would be required. The products must be handled in a sanitary fashion and technological apparatus should be available to make the operation efficient. Several procedures and recommendations have been discussed.

The control of injurious organisms is of prime importance in the successful cultivation of any organism, including molluscs. Control of pests in the aquatic environment is not as easy as terrestrial control nor have as many techniques been developed, although considerable information exists. Control can be achieved mainly by removing the pests, modifying techniques of culture, using chemical pesticides, and developing genetically resistant strains.

It is recommended that shellfish hatcheries be established. Hatcheries are very important in modern maricultural practices, not only as a reliable source of young for planting purposes but also as a means of domesticating and improving the molluscs. Strains can be selected for such characteristics as better growth, better adaptability to the environment and other desirable traits. It may be possible to produce hybrid seed to improve the crop and to take advantage of hybrid vigour through selection of segregants.

There is a good possibility that clam mariculture, using hatchery-reared hybrid seed clams between the northern and southern species, and providing protection from predators would be successful. The native mangrove oyster, *Crassostrea rhizophorae*, can be managed to increase the supply of it. Another possibility is to introduce an exotic oyster species that is adapted to the tropical region and is superior to the native species in commercial possibilities. Several species were suggested that might be successful. Hatchery-produced hybrids between the native oyster and a larger species might prove desirable for oyster mariculture.

Suggestions are made for establishing a hatchery to rear the queen conch, *Strombus gigas*, planting them in areas protected from predators, and manipulating the area for increased algal growth for a food supply. The fishery for queen conchs is already an important one in many areas and every effort should be made to increase the supply.

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EL OSTION DEL MANGLE *Crassostrea rhizophorae* GUILDING 1828 (ALGUNAS OBSERVACIONES SOBRE SUS DIMENSIONES, PESOS Y SEXOS)

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1 INTRODUCCION

El ostión del mangle es un recurso de la plataforma cubana de considerable importancia. Debido al interés que existe en su explotación racional y posible cultivo es necesario conocer algunas sus características morfológicas, su crecimiento (en tamaño y peso) y su reproducción.

En este trabajo se exponen algunos resultados de las investigaciones realizadas con este propósito.

2 MATERIAL Y METODOS

Para llevar a cabo las observaciones se realizaron 4 461 mediciones de tamaños y 5 948 pesadas en 1 487 ejemplares pertenecientes a las clases de tamaño comprendidas entre 32 y 77 mm, que son las más frecuentes en las recolectas comerciales. Todas ellas fueron tomadas en las siguientes áreas ostrícolas:

Cabañas (Laguna de Mala Habitación - Costa Norte, Provincia de Pinar del Río)

Casilda (Estero Jobabo, Estero Nuevo y Puerto Mario - Costa Sur, Provincia de Las Villas)

Isabela de Sagua (varios cayos adyacentes - Costa Norte, Provincia de Las Villas).

Para medir las conchas se utilizó un calibrador llamado "pie de rey". Las medidas tomadas en milímetros se agruparon en clases de 3 mm utilizando el punto medio como representante de cada clase (ejemplo: 32 para tamaños entre 31 y 33 milímetros).

Las pesadas, expresadas en décimas de un gramo, se efectuaron con una balanza de triple brazo. Primero, se limpió cuidadosamente la concha y se tomó su peso total. Seguidamente se separó la parte comestible de la concha depositando ambas partes sobre papeles absorbentes con el propósito de eliminar el resto del agua intervalvar. Finalmente se efectuaron las pesadas de cada una de las partes.

La determinación del sexo se realizó mediante examen microscópico, presionando o lesionando la gónada y separando con la punta de un bisturí algo de líquido saliente del poro genital o de la herida producida.

4.31

3 ALGUNOS DATOS SOBRE EL OSTION DEL MANGLE

Guilding (1828) que fue el primero en describir la especie, dice que el ostión se adhiere en número considerable a la corteza de las raíces del mangle rojo y a las demás valvas de la misma especie, formando así racimos. En base a esta característica lo denominó "ostión del mangle". Los ostiones tienen sus conchas subtriangulares en general ovaladas y alargadas, liveramente cóncavas hasta profundas, foliáceas y relativamente ligeras. Ambas valvas son asimétricas. La valva derecha vista lateralmente tiene forma de letra "S". La valva izquierda es cóncava y a veces muy profunda. Ambas valvas son más gruesas en su parte anterior y poseen márgenes posteriores muy finos. El periostraco generalmente presenta coloración purpúrea, café, amarilla, gris y verde así como combinaciones de estos colores. Los umbos son encorvados hacia la parte dorsal (Figura 1). El área de inserción del músculo aductor tiene forma similar a una media luna y generalmente no está pigmentada. Los bordes del manto son amarillentos, variando hacia el color del tabaco claro. La cámara promyal está presente. Los ovulos y espermatozoides son expulsados directamente al agua marina donde ocurre la fecundación. Las larvas tardan hasta 48 h para su desarrollo y la fijación tiene lugar inmediatamente después.

El crecimiento es relativamente rápido debido a que el ostión adquiere el tamaño mínimo comercial de 5 cm entre los 5 y los 7 meses de edad.

Los ostioneros dan a los ostiones adheridos a las raíces aéreas y ramas terminales el nombre de guirnaldillo o guindardillo. Otros encontrados sobre las raíces terrestres y algunas ramas principales reciben el nombre de ostiones de pared o de uña. A los que se agrupan en racimos sobre las raíces aéreas los nombran ostiones en piña o de maceta.

Todo parece indicar que se trata de dos variedades ecológicas con las siguientes características principales:

(i) El ostión adherido a las raíces terrestres y a algunas ramas principales tiene valvas de color blanco, grisáceo o verdoso, probablemente por abundante calcificación, microdepósitos de lodo y crecimientos de algas microscópicas. Generalmente carece de periostraco y las valvas son relativamente gruesas y fuertes, de forma ovalada u alargada. Estos ostiones normalmente no forman "pinas" y se separan con dificultad del substrato.

(ii) El ostión adherido a las raíces aéreas y ramas terminales tiene el periostraco teñido de color tabaco, café, amarillento hasta morado probablemente por el tanino que se desprende de la corteza del mangle rojo (el substrato). Las valvas son finas y frágiles con "áreas" transparentes sin calcificación. Generalmente tienen forma subtriangular (ovalada y alargada) pero las hay, aunque en número mucho menor, redondeadas o sin determinada forma. Frecuentemente forman racimos llamados "piñas" y macetas. Estos se separan del substrato con menos dificultad que los anteriormente descritos.

4 RELACIONES ENTRE LAS PRINCIPALES DIMENSIONES Y LOS PESOS DE DISTINTAS PARTES DEL OSTION

Existen ciertas confusiones entre los científicos y los prácticos acerca del empleo de los términos aplicables a algunas dimensiones de la concha. En el presente trabajo se utilizaron los siguientes términos para las tres dimensiones principales:

(i) Altura - Al - (Longitud 1/) distancia máxima tomada entre el umbo y el margen opuesto de la concha;

(ii) Anchura - An- (Altura 1/) distancia máxima entre los márgenes de la concha tomada paralelamente al eje de la charnela;

(iii) Profundidad - P - (Anchura 1/) distancia máxima entre las superficies externas de ambas valvas cerradas.

Se tomaron los siguientes pesos: peso total (Pt), peso de la concha (ambas valvas, Pch) y peso de la parte comestible ("carne" Pc). El peso del agua intervalvas (Pa) se obtuvo por diferencia Pa= Pt- (Pch + Pc).

1/ Los nombres entre paréntesis son usados por los prácticos

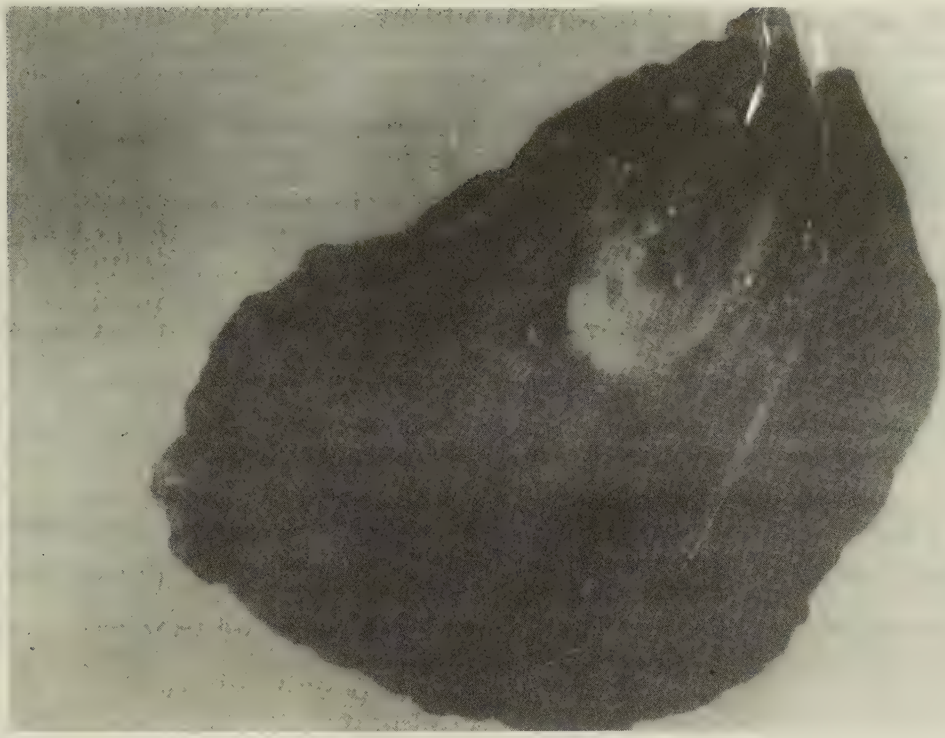

Fig. 1 El ostión del mangle

Para estudiar las relaciones entre las distintas medidas de la concha se tomó como base su altura (longitud) la cual a su vez se usa como medida práctica para determinar el tamaño del ostión. Según se ha podido ver en el capítulo anterior, los ostiones del mangle difieren considerablemente en las formas de sus conchas. Representaciones gráficas de relaciones entre sus diferentes planos dimensionales tienen la tendencia a ser curvilíneas (Figura 2). En base a la clasificación de ostiones de acuerdo a sus formas, que se mencionará a continuación, se obtuvieron los siguientes datos: de 1 482 individuos observados 2.9 por ciento tenían forma redondeada, 44.5 por ciento ovalada, 40.7 por ciento alargada (prolongada) y 11.9 por ciento no tenían forma determinada (irregular). La mayoría de los individuos observados eran de forma ovalada y alargada (85.2 por ciento). Por lo tanto, estas dos formas determinan el gráfico de la Figura 2. Si se comparan los datos de anchura y de profundidad para cada una de estas dos formas separadamente con los datos presentados en la Figura 2, se encuentra que los valores correspondientes a la forma ovalada se situan siempre por encima de aquellos de forma alargada con tendencia a una gráfica curvilínea.

A continuación se presentan algunos ejemplos de relaciones entre las distintas dimensiones para individuos mayores de 77 mm (Al), los que son menos frecuentes en recolectas comerciales:

Ejemplo No.	1	2	3	4	5	6	7	8
N	25	12	5	2	5	3	1	2
Altura (Clase mm)	80	83	86	89	92	95	98	101
Anchura	44.2	42.0 1/	44.0	52.5	42.6	48.0	60.0 2/	47.0
Profundidad	15.6	13.9	15.0	15.5	16.6	19.6 2/	12.0 1/	16.5

1/ Tamaños minimos   2/ Tamaños máximos

Para estudiar las relaciones entre el peso de varias partes del ostión se utilizó como base los pesos totales individuales distribuídos en la abscisa de un sistema de coordenadas entre 5 y 26 gramos. Utilizando técnicas de regresión lineal se obtuvieron las siguientes ecuaciones:

$Poh = -0.04 + 0.696\ Pt$ (relación entre el peso de la concha y el peso total).

$Pc = 0.30 \not+ 0.118\ Pt$ (relación entre el peso de la "carne" y peso total) (Figura 3). Esta representación gráfica demuestra que ambas líneas rectas trazadas se ajustan bien a los datos obtenidos.

La relación más importante para fines prácticos es la que se obtuvo entre el peso de la carne y peso total. Con el ajuste de una recta que pasa por el origen del sistema de coordenadas se obtiene la relación $Pc = 0.134\ Pt$, lo que significa que la carne aporta al peso total un 13.4 por ciento.

Los datos observados entre el peso y la altura (longitud) de la concha sugieren que existe una relación rectilínea entre el peso total (también entre el peso de la concha más el peso de la "carne") y la altura de la concha. Las líneas rectas trazadas obtenidas con las técnicas de regresión lineal se ajustan a los datos observados. Se calcularon 3 rectas de regresión y se obtuvieron las siguientes ecuaciones:

$Pt = -12.9 \not+ 0.512\ Al$, o sea, la relación entre el peso total y la altura de la concha;

$Poh = -9.23 \not+ 0.356\ Al$, o sea, la relación entre el peso de la concha y la altura de la misma;

$Pc = -1.21 \not+ 0.060\ Al$, o sea, la relación entre el peso de la "carne" y la altura de la concha (Figura 4).

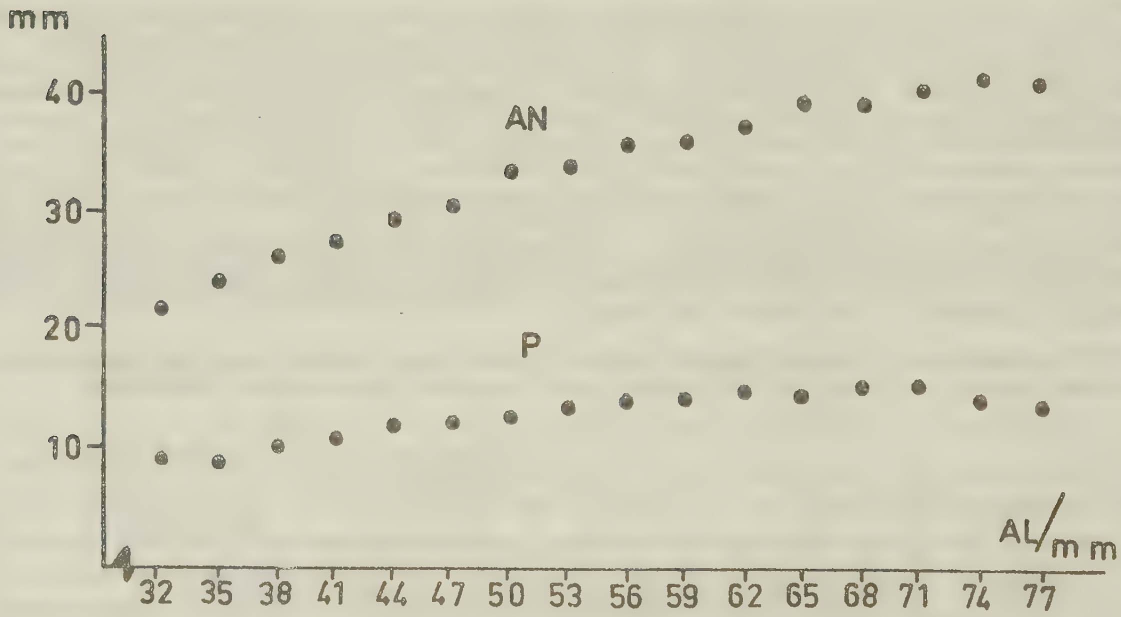

Fig. 2 Relaciones entre altura (Al) anchura (An) y profundidad (P) en el ostión del mangle

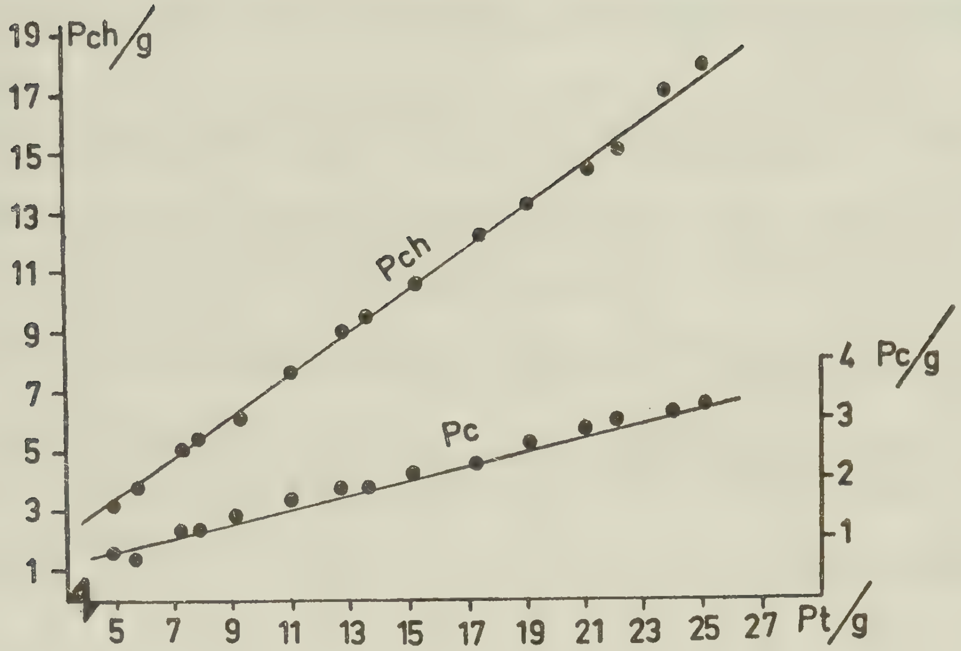

Fig. 3 Relaciones entre peso carne (Po) peso concha (Poh) y peso total (Pt)

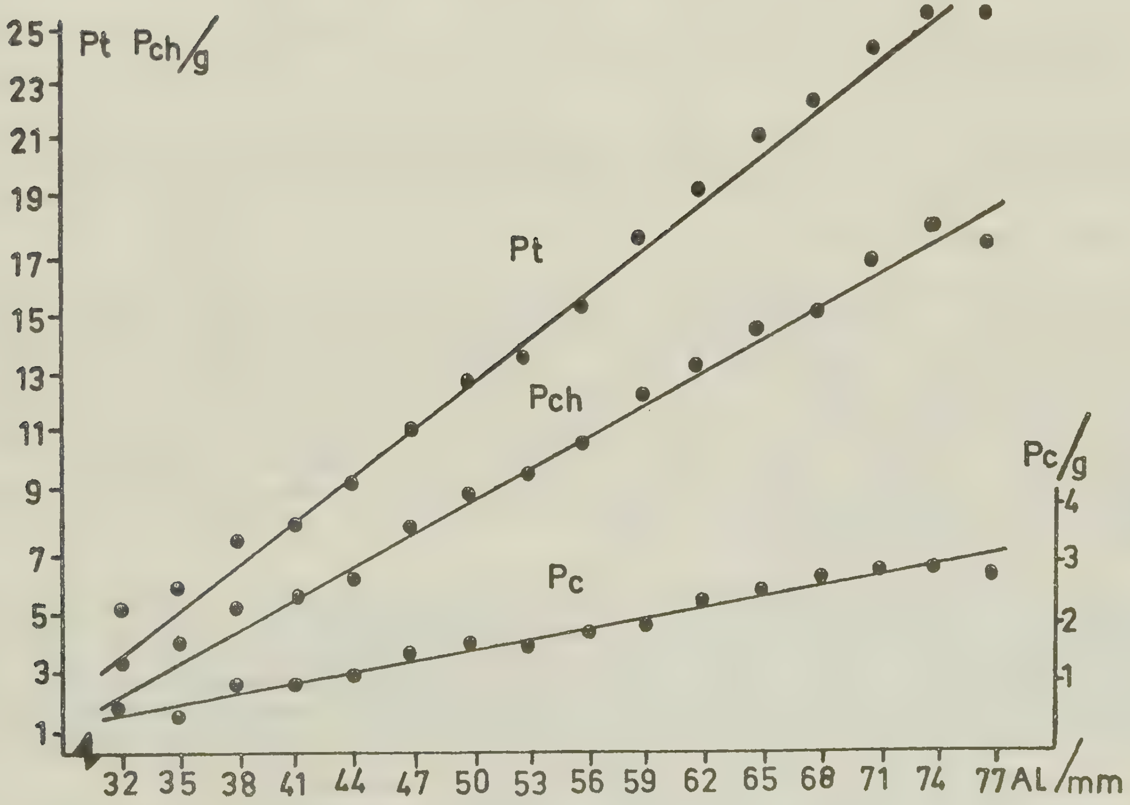

Fig. 4 Relaciones entre peso total (Pt) peso concha (Poh) peso carne (Po) y altura de la concha (Al).

4.31

A continuación se presentan ejemplos de las relaciones entre pesos de distintas partes y la altura en individuos mayores de 77 mm (clases milimétricas entre 80 y 101 mm) los que son menos frecuentes en recolectas comerciales:

Ejemplo No.	1	2	3	4	5	6	7	8
N	25	12	5	2	5	3	1	2
Clase mm	80	83	86	89	92	95	98	101
Peso total promedio en g	30.0	25.4[1]	30.1[1]	43.0	28.1	52.7[2]	34.1	40.7
Peso de la concha promedio en g	20.9	17.8[1]	19.7	30.2	18.5	38.1[2]	29.0	25.6
Peso de la "carne" promedio en g	4.0	3.4	3.3[1]	5.7	3.6	6.4[2]	5.1	4.4

1/ Pesos mínimos   2/ Pesos máximos

La mayoría de los individuos de tamaños entre 80 y 101 mm tenía entre 3 y 6 g y algunos entre 6 y 8 g de "carne". Un ejemplar alcanzó 8.6 g de carne (Al = 90, An = 62 y P = 19 mm; Pt = 62.7 y Pch = 46.1 g) y otro, 9.8 g de carne (Al = 96, An = 54 y P = 20 mm; Pt = 62.1 y Pch = 44.3 gramos).

5 SEXO Y MADURACION GONADAL

El sexo de los ostiones se determinó microscópicamente debido a que no tienen ningún carácter sexual secundario. La gonada completamente desarrollada es el órgano de mayor dimensión del ostión y ocupa un tercio del volúmen de su cuerpo. Los ostiones tienen sexos separados. El menor macho encontrado medía 14 mm (Isabela de Sagua, 1964) y la menor hembra 19 mm (Isabela de Sagua, 1964). Los individuos sexualmente maduros de menor tamano pertenecían a las clases 29 y 32 mm en Casilda e Isabela de Sagua respectivamente. En Casilda había en 1964, 39.4 por ciento de machos, 59.0 por ciento hembras y 1.6 por ciento de individuos de sexo indeterminado (N = 816). En Isabela de Sagua había durante el año 1965, 38.4 por ciento de machos, 61.3 por ciento de hembras y 0.3 por ciento de individuos en los cuales no se pudo determinar el sexo (N = 294). Durante el año 1966 se encontró en Casilda 39.8 por ciento de machos, 59.7 de hembras y solamente un 0.5 por ciento de individuos en los cuales no se pudo determinar el sexo (N = 565).

Para fines prácticos se determinaron diversos estadios en el desarrollo de las gónadas basados en observaciones macroscópicas. Entre los 1 303 individuos distribuídos entre 32 y 77 mm que se estudiaron con este propósito en los años desde 1964 a 1966, había solamente un 32.3 por ciento de machos (Cabañas 33.6 por ciento, Casilda 31.9 por ciento e Isabela de Sagua 32.1 por ciento). Entre los machos se encontró un 44 por ciento y entre las hembras, un 32.2 por ciento de ejemplares menores de 50 mm (en tamaño de su concha). Había aproximadamente un 2.5 por ciento de individuos en los cuales no se pudo determinar el sexo. El 70 por ciento de éstos pertenecía a tamaños menores de 50 mm.

Las descripciones de los diferentes estadios se dan a continuación:

Estadio 0: Gónada translúcida de color grisáceo verdoso o amarillento claro. El ostión parece magro y como lleno de agua. La gónada está vacía ("virgen").

Estadio 1: La gónada cubre una parte menor de la masa visceral y tiene el color blanco hasta marfil; su volumen ha aumentado muy poco. La gónada se encuentra en desarrollo.

Estadio 2: La gónada cubre gran parte de la masa visceral y tiene color marfil. Su volumen ha aumentado considerablemente, pero los gametos no salen del poro genital aún cuando se aplica gran presión sobre la misma. Lesionándola se obtiene generalmente óvulos poligonales o en forma de pera y espermatozoides inmóviles. La gónada se encuentra en proceso de maduración.

Estadio 3: La gónada cubre casi totalmente la masa visceral y tiene color de marfil viejo; los gonoductos son muy visibles. Los gametos salen del poro genital bajo leve presión. Los óvulos son redondos y los espermatozoides movimentados. Durante el desove, el agua cercana al ostión adquiere un color lechoso. La gónada está madura, apta para desovar.

Estadio 4: Se observa la regresión en el volumen de la gónada. La parte anterior es nuevamente translúcida. Al presionarla se pueden obtener muy pocos gametos. Hay cambio de color hacia un tono gris. La gónada se encuentra en la base de inactividad sexual y regeneración.

Más del 50 por ciento de los individuos que componían estas muestras se encontraba en el estadio 4 y el resto estaba repartido entre los demás estadios, correspondiendo al estadio 0 el menor número de ejemplares (aproximadamente un 5 por ciento). La mayoría de éstos tenía tamaños menores de 50 milímetros.

Utilizando este método se encontró la siguiente distribución por estadios en distintas areas y temporadas:

Area Mes, Año	N	Frecuencia de estadios, en por ciento				
		0	1	2	3	4
Casilda Julio - 1964	322	5.6	7.7	13.1	16.1	57.5
Casilda Septiembre-1964	114	23.7	31.5	23.7	14.0	7.1
Isabela de Sagua Septiembre - 1964	250	6.4	27.6	26.4	16.6	24.0
Casilda Octubre - 1964	108	25.0	13.8	49.1	12.1	0
Casilda Noviembre - 1964	95	1.0	71.6	0	27.4	0
Casilda Marzo - 1965	79	1.3	15.2	51.9	26.5	5.1
Cabañas Julio - 1965	190	2.1	14.8	6.8	41.0	35.3
Casilda Agosto-Sept-1965	147	0	4.1	14.9	29.2	51.8
Isabela de Sagua Diciembre - 1965	101	0	5.9	2.0	0	73.1
Casilda Abril - 1966	83	0	34.9	21.7	25.3	18.1

6 CONCLUSIONES

El ostión del mangle tiene básicamente forma subtriangular, la que puede presentar las siguientes variaciones: redondeada (2.9 por ciento), ovalada (44.5 por ciento), alargada (40.7 por ciento) y sin forma determinada (11.9 por ciento). Hay que pequeñas diferencias morfológicas entre los ostiones adheridos a las ramas y raíces aereas y los ostiones que habitan en las raíces terrestres. Quizás se trata de dos variedades ecológicas (estacionales).

Para establecer el tamaño de cada individuo se utilizó su altura (longitud) que es a su vez la mayor dimensión del ostión. Las relaciones entre los distintos tamaños tienen tendencias curvilineales.

Los datos obtenidos de las relaciones entre los pesos de diferentes partes del ostión se ajustan graficamente a las lineas rectas. Con el ajuste de la recta que pasa por el origen del sistema de coordenadas se obtiene la relación que sirve para el uso práctico, por ejemplo: (Peso del cuerpo = .134 Pt).

Los datos sobre la relación entre el peso de distintas partes y una dimensión (altura) del ostión también pueden expresarse graficamente en lineas rectas.

Uno de los ostiones muestreados tenía una altura de 118 mm, algunos alcanzaron entre 80 y 101 mm de altura. Las otras medidas y pesos fueron las siguientes: anchura entre 42.0 y 60.0 mm, profundidad entre 12.0 y 19.6 mm, peso total entre 25.4 y 52.7 g, peso de la concha entre 17.8 y 38.1 g y peso del cuerpo entre 3.3 y 6.4 gramos. Había individuos que tenían 8.6 g (altura = 90) y 9.8 g (altura = 96) de "carne".

Aproximadamente el 40 por ciento de los individuos que forman parte de las poblaciones en el mangle eran machos (32.3 por ciento de individuos pertenecientes a tamaños entre 32 y 77 milímetros). En una pequeña parte de los ostiones estudiados (0.5 y 2.5 por ciento) no fué posible determinar el sexo. Se establecieron 5 estadios en el desarrollo de las gonadas. De los estudios se desprende que el desove ocurre durante todo el año con menor o mayor intensidad y depende de las condiciones ecológicas y de las temporadas del año. La intensidad máxima de desove, or sea, cuando la mayoría de los individuos se encontraba en los estadios 2 y 3 se observó entre marzo y junio; otro desove menos intensivo ocurrió entre (septiembre) octubre y noviembre. Durante julio y agosto (septiembre) así como en el período de diciembre a febrero, la mayoría de las gónadas se encontraban el los estadios 4, 1 y 0.

7 REFERENCIAS

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1828 3(12):527-44

EL OSTION DEL MANGLE *Crassostrea rhizophorae* GUILDING 1828
(EXPLOTACION DEL RECURSO Y POSIBILIDADES PARA EL CULTIVO)

por

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1 INTRODUCCION

Según los datos disponibles, el ostión del mangle (*Crassostrea rhizophorae* Guilding 1828) vive en aguas marinas costeras de varios paises del Caribe. Es un recurso pesquero de importancia debido a que puede aportar a la dieta humana un alto porcentaje de proteinas de facil digestión.

Las investigaciones que se relatan en el presente trabajo se realizaron durante los años 1964-68 en las mayores áreas productoras de ostiones a lo largo de las costas cubanas y especialmente en Cabañas (costa norte), Casilda (costa sur) e Isabela de Sagua (costa norte). Los experimentos de cultivo se desarrollan en el área de Casilda.

Para cada estudio de una población se recolectaron en el mangle aproximadamente 500 ostiones al azar; para cada estudio de recogidas se muestreó por lo menos 1 "lata" (capacidad 20 l) que proporcionó también alrededor de 500 ostiones. Como longitud de la concha se midió la mayor distancia, tomada con un calibrador (pie de rey), entre el umbo y el margen opuesto de la concha. Para cada estudio de colectores se tomaron como mínimo 10 unidades al azar. Las medidas obtenidas en milímetros se agruparon en clases de 3 mm utilizando el punto medio como representante de cada clase.

Deseamos agradecer a todos los ostioneros cubanos que facilitaron de un modo u otro el desarrollo de dichas investigaciones y especialmente a Juan Deas Roa, Braulio Luján y Pedro Matamoros de Casilda.

2 EXPLOTACION DEL RECURSO

2.1 Características del habitat

Los ostiones del mangle están adheridos a la corteza de las ramas, raices áereas y terrestres del mangle rojo (*Rhizophora mangle* L.) un arbusto que forma parte del manglar bordeando ensenadas, lagunas, esteros, zanjas, ríos, etc. Prefieren los lugares protegidos de oleajes fuertes, pero necesitan pequeños afluyentes de agua dulce y corrientes marinas con velocidades entre 10 y 60 cm/sec. La distribución río arriba depende de la salinidad (limites entre 26 y 37 por ciento). Verticalmente ocupan el nivel de las mareas, o sea, eulitoral (en Cuba aproximadamente 40 cm) pero la mayoría de ellos vive en el nivel intermedio de éste que comprende solamente 15 cm de altura. Hay muy escasos ostiones en el nivel siempre sumergido (sublitoral) debido a la fuerte competencia interespecífica por espacio y alimento (Fig. 1). Los organismos asociados pertenecen a los siguientes grupos: algas, esponjas, turbelarios, gasterópodos, bivalvios (mejillones, bayas, ostiones, etc.), crustáceos (escaramujos, cangrejos), poliquetos, tubícolas, ofiuroideos, ascidias y synascidias, etc. Se conocen varios epibiontes (algas var. sp., ostiones, bayas, mejillones, escaramujos, synascidias) y algunos endobiontes (polipo—*Eugymnanthea crassostreae* que habita en las branquias del ostión, esponja—*Cliona* sp. y anélido *Polydora hoplura* (Claparède) que perforan sus valvas). Los principales enemigos del ostión del mangle son los gasterópodos *Murex brevifrons* Lamarck y *Melongena melongena* Linné así como el crustáceo *Panopeus herbstii*

Milne Edwards, los cuales rompen sus conchas y se alimentan de su parte blanda.

2.2 Sobre la composición de la población

Algunos datos morfológicos sobre el ostión del mangle fueron dados a conocer por Nikolić y Alfonso Meléndez 1968, Nikolić y Soroa (MS).

Su crecimiento es relativamente rápido debido a que alcanzan tamaño comercial (50 mm) entre los 5 y 7 meses de edad. Pero se encontró también individuos que crecían 89 mm en 7 meses y más de 100 mm en 9 meses. El individuo de mayor tamaño encontrado, aunque se desconoce su edad, medía 118 milímetros.

Sobre la composición de la población ostionera se efectuaron varios estudios en distintas áreas a lo largo de la costa cubana.

Batabanó (Punta Arenas) es un área de la costa sur donde la recolección no se practicaba en los últimos 5 anos. Un análisis de población en dicha área realizado en agosto de 1966 proporcionó los siguientes resultados: los ostiones alcanzaron tamaños entre 5 y 92 mm con clases modales 49 y 59 milímetros. 73,4 por ciento de ellos eran mayores de 50 mm y un 19.1 por ciento habían muerto.

Casilda (Estero Nuevo) pertenece a un área vedada debido a que allí se realizan experimentos con cultivos. Se tomaron muestras en distintos meses del año 1966 obteniéndose los datos anotados en Cuadro I.

CUADRO I

Distribución por tamaños entre ostiones de Casilda durante distintos meses de 1966

1966	Ene.	Feb.	Mar.	Abr.	Jul.	Sep.
Distribución por clases en milímetros	8-65	38-92	29-95	32-92	8-71	14-80
Clases modales en milímetros	41 y 53	71	71	59	53	29 y 50
Mayores de 50 milímetros por ciento	19,9	84,1	86,9	76,5	71,1	53,3

La generación que se instaló en el mangle aproximadamente en el mes de septiembre 1965, tenía en enero de 1966 individuos de un tamaño de 65 mm (clases modales 41 y 53) y en marzo, de 95 mm (Mo = 71 milímetros). En abril empezó la desaparición de tamaños mayores (Mo = 59) debido que algunos de estos individuos se separaron y cayeron al fondo por el aumento de su peso. En julio apareció una nueva generación (Mo = 17). Durante estos meses hubo entre 5 y 10 por ciento de individuos muertos.

Playa Florida (Esteros Santa María, Remate, La Toyosa y Cañaones). Se encuentra en la costa sur. La última recogida se realizó con dos y medio meses de anterioridad a este estudio.

Los ostiones estudiados en agosto de 1966 estaban distribuidos entre clases de 2 y 77 mm (Mo 11, 29, 41 milímetros). Había solamente 1,6 por ciento de tamaños mayores de 50 mm y 5,18 por ciento de muertos.

En Puerto Padre (Río Zanja) - área de la costa norte donde la recolección se realiza periódicamente - había en septiembre de 1966 una distribución por tamaños entre 8 y 68 mm (Mo = 26 mm) y 5,0 por ciento de individuos muertos. Entre los vivos solamente un 12,6 por ciento alcanzó tamaño comercial.

Nuevitas (Estero Boca Grande) representa un área en la costa norte donde la recolección no se realiza todavía, debido a la destrucción del mangle producida por el ciclón "Flora" (octubre 1963). En septiembre de 1966 se encontraron ostiones con un tamaño entre 5 y 62 mm (Mo = 32 mm) y 12,0 por ciento de individuos

4.30

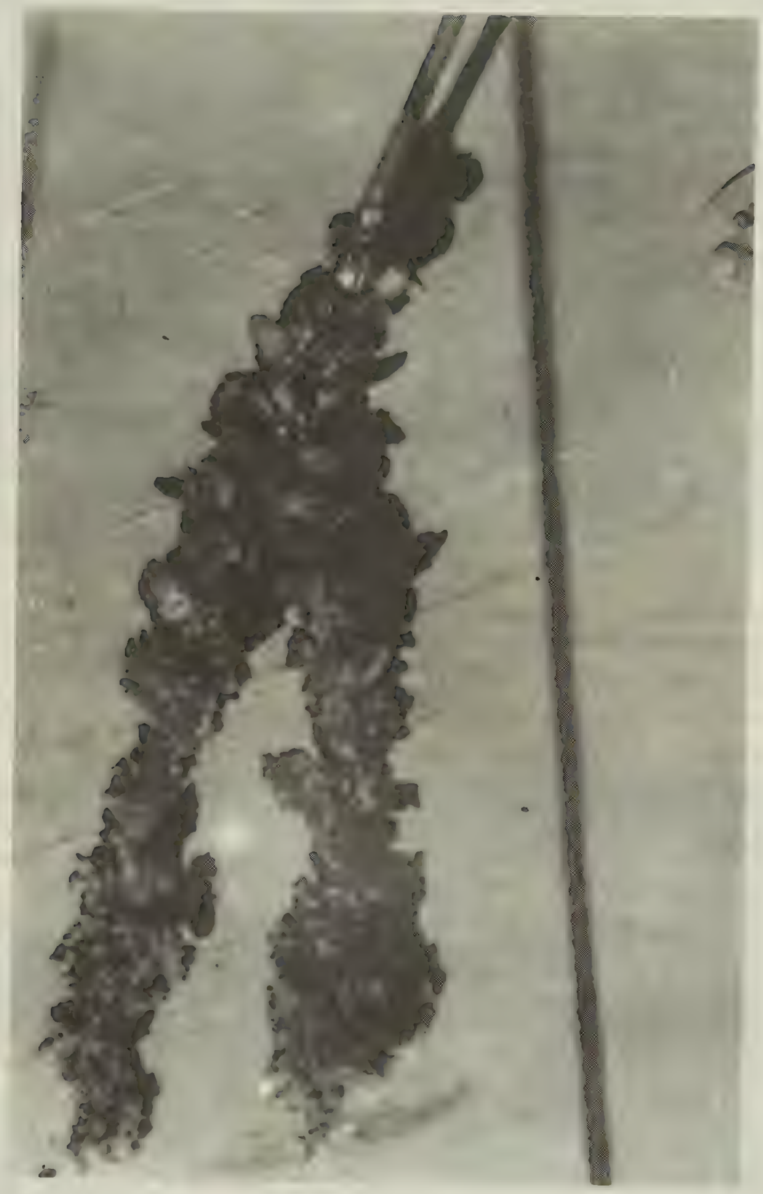

Fig. 1 Una rama de mangle rojo poblada por distintos organismos sésiles. La parte superior (eulitoral) son ostiones y la parte inferior (sublitoral) varios otros organismos

muertos. Entre los que estaban vivos solamente 3,7 por ciento pertenecían a la clase de tamaño comercial.

En el área de Isabela de Sagua (costa norte) los ostiones habitan en los cayos adyacentes donde la recolección fué muy intensa en años anteriores. Durante los estudios realizados en septiembre de 1964 se encontraron ostiones de tamaños entre 14 y 98 mm con muy escasos individuos mayores de 62 mm (Mo = 29, 50, 59 milímetros). Había un 12,3 por ciento de individuos mayores de 50 mm y 11,2 por ciento de muertos.

2.3 Artes y métodos de recolección

Hace mucho tiempo que en la recolección de ostiones del mangle se utilizan el machete, los guantes de lona y un cesto hecho de yagua de palma real (*Roystonea regia* (H.B.K.) O.F. Cook) para depositar el producto de la faena. Los ostioneros registraban el mangle caminando por el fondo lodoso sumergidos en el agua hasta las cinturas (Fig. 2). Recientemente se emplea una embarcación llamada "bongo" que hace la recolección menos difícil y más efectiva (Fig. 3).

Se analizaron las recogidas en dos áreas ostioneras importantes (Casilda e Isabela de Sagua, 1965) en base a un recipiente standard que generalmente se usa por los ostioneros: "lata" y que tiene aproximadamente 20 l de capacidad.

CUADRO II

El número y el peso de los ostiones en cada envase ("lata")

Lata	Casilda	Isabela de Sagua
No. de ostiones	548,8	483,5
Por ciento de tamaño comercial	30,3	34,8
Peso total de ostiones - sin limpiar conchas - en gr	9 521	9 485
Peso total de ostiones - con conchas limpias - en gr	8 404	8 607

Resumiendo el cuadro anterior en números aproximados resulta que una "lata" contiene 500 ostiones de los cuales 32,5 por ciento son mayores de 50 mm y el peso de todos los ostiones con las conchas sin limpiar es 9,5 kg y con las conchas limpias es de 8,5 kilogramos.

El resultado de la recolección en kg por recolector/día fué el siguiente:

Recolección en kg / Año	Casilda		Isabela de Sagua	
	Min.	Max.	Min.	Max.
1964	81,7	137,7	29,4	86,4
1965	69,3	106,4	41,8	82,5
1966	89,3	126,3	42,7	75,0

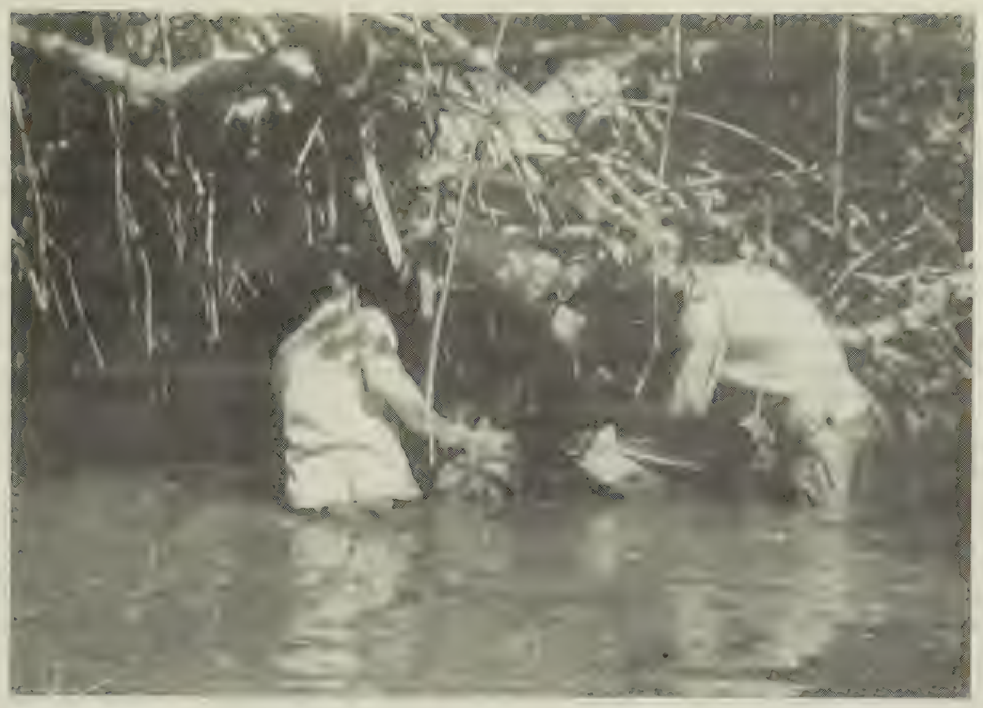

Fig. 2 Recolección de ostiones primitiva y menos efectiva

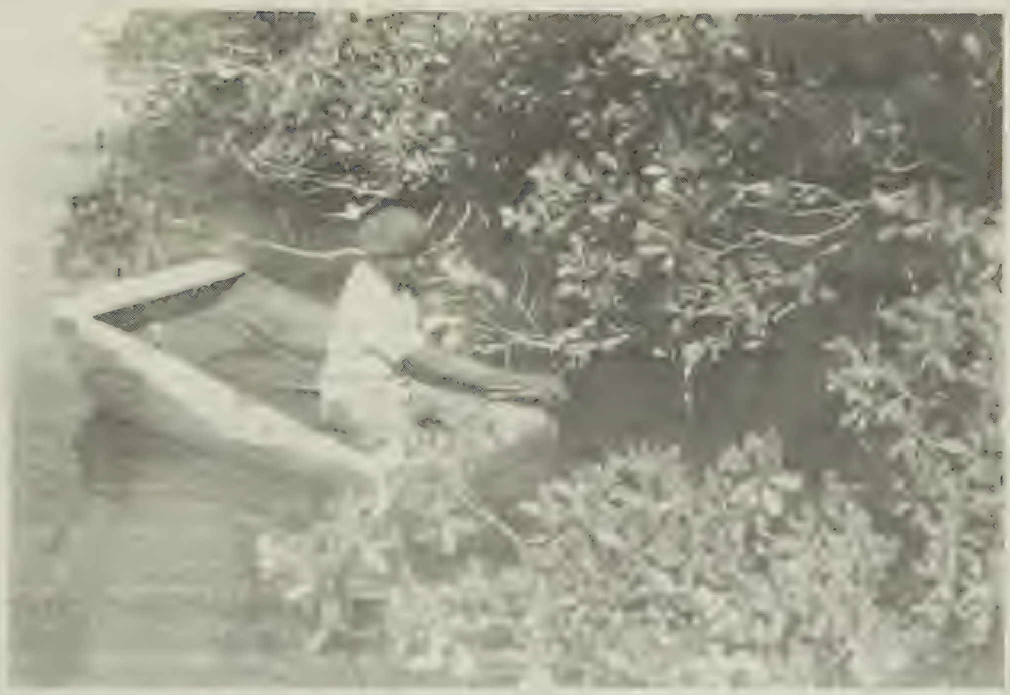

Fig. 3 Un méthodo de recolección de ostiones con mejores resultados en las recogidas

2.4 Manejo y medidas de conservación del recurso

El manejo del recurso ostión consiste principalmente en el control de factores que regulan el suministro de excedentes destinados a la explotación. La continuidad de tal suministro depende de la relación entre mortalidad anual (mortalidad natural más mortalidad ocasionada por la recolección) y reclutamiento anual de tamaños comerciales.

Estos hechos están condicionados por varios factores, principalmente de orden natural, pero también el hombre a traves de distintas actividades influye sobre dicho recurso.

Bruscos cambios de factores físicos y químicos en el habitat pueden eliminar áreas ostioneras completas. Lluvias torrenciales y vientos huracanados pueden destruir los manglares y los ostiones adheridos a sus ramas y raices. Las aguas turbias por la presencia de lodo y la disminución de la salinidad a consecuencia de abundantes lluvias ejercen una influencia negativa en la vida del ostión. Competidores y enemigos naturales determinan en muchas ocasiones en qué volumen estará representada la población ostionera en un área.

El hombre influye en la producción de excedentes del ostión por medio de:

2.4.1 Recolección indiscriminada

Debido a que los ostiones crecen en racimos, la separación y recolección de individuos de tamaño comercial es difícil y necesariamente resulta en considerables pérdidas de los ostiones menores. En las poblaciones naturales hay entre 1,6 y 86,9 por ciento de ostiones de tamaño comercial y este porcentaje depende del área y de la temporada. Si la explotación se lleva a cabo indiscriminadamente en dos or tres años la población puede llegar a desaparecer. La repoblación natural tarda entre dos y tres años y en algunos casos no se produce. Para evitar estos fenómenos negativos se debe proceder a la explotación de manera racional. En primer lugar deben disminuir las pérdidas de ostiones menores de 50 mm y a su vez deben respetarse siempre varios ostiones mayores (aproximadamente 5 por ciento) que sirvan de inmediato como reproductores. En el caso de haber ocurrido ya una disminución considerable de la población puede ser de utilidad la repoblación artificial.

Tales experimentos se realizaron en 1966 en el área de Casilda, que carecía de ostiones desde hacía años. Se procedió a colocar en el área La Barca (Mayo 1966) aproximadamente 1 000 colectores del tipo rama de mangle rojo con fijación de ostiones de tamaños entre 5 y 26 mm (Mo = 17 milímetros). Dos meses y medio después, los ostiones alcanzaron tamaños entre 8 y 77 mm (Mo = 53 y 62 milímetros). Además se apreció un considerable número de fijaciones sobre las ramas y raices del mangle cercano (Mo = 32).

2.4.2 Corte del mangle rojo

El corte del mangle rojo que bordea las areas ostioneras es sumamente dañino debido a que disminuye o elimina por completo el área de fijación para los ostiones y destruye el medio ambiente que sirve como protección para estadios postlarvales, juveniles y adultos de otras especies importantes como la langosta, el camarón, etc., sin considerar el daño que puede causar en la protección y formación de las costas.

2.4.3 Contaminación (polución) de las aguas

Esta puede ser de orden físico-químico y biológico. La contaminación afecta a los ostiones directa o indirectamente. Con el aumento del lodo suspendido en el agua pueden ser dañadas o destruidas sus branquias, con la desalinización del agua aumenta a presión osmótica en los tejidos y con la disminución del oxígeno se afecta la respiración. Cuando el lodo cubre los substratos disponibles para la fijación de las larvas o cuando las condiciones ecológicas cambian de tal manera de ser perjudiciales únicamente para los organismos que sirven a los ostiones como alimento, entonces el perjuicio es indirecto. Muchas veces se combinan diversas causas y el efecto es mucho más grave ocasionando la muerte del ostión.

El ostión del mangle ofrece una cierta resistencia a las condiciones desfavorables, debido a que puede mantener cerradas sus valvas herméticamente de 3 a 7 días, según los resultados de experimentos en el laboratorio. Pero si las condiciones desfavorables persisten, la muerte es inevitable.

El consumo de ostiones puede ser peligroso cuando provienen de aguas bacteriológicamente contaminadas aún en el caso que estas no sean perjudiciales para los ostiones mismos.

3 POSIBILIDADES PARA EL CULTIVO

Con el cultivo bien dirigido se puede aumentar considerablemente la producción de ostiones en un determinado área, y tener a su vez control sobre el porcentaje de tamaños aptos para el consumo, controlar a los enemigos naturales y mejorar la calidad de su parte comestible.

En vez de recorrer extensas áreas a lo largo de la costa en busca de ostiones existe la posibilidad de establecer con pocos recursos el cultivo de ostiones en un área de unos cuantos centenares de metros cuadrados.

Con este fin se escogieron áreas apropiadas, se construyeron instalaciones adecuadas empleándose distintos colectores y cultivos. Los resultados obtenidos fueron descritos por Nikolić y Alfonso Meléndez (1968); otros más recientes se describirán a continuación.

3.1 Areas

Cada área destinada al cultivo de ostiones del mangle debe reunir las siguientes condiciones elementales: profundidad del agua entre 1 y 2 metros para facilitar la construcción de las instalaciones necesarias, salinidad del agua entre 28 y 36 °/oo (con pequeños afluyentes de agua dulce), concentración de oxígeno en el agua entre 2 y 5°/oo, débiles corrientes marinas que proporcionan nuevas masas de agua (10-60 m/sec), adecuada protección contra el oleaje excesivo (natural o artificial y agua libre de contaminación (polución)).

Se pueden establecer dos áreas, no muy lejanas, una para capturar larvas (fijaciones) y otra donde se practicará el cultivo. El traslado de las fijaciones del área de desove al área de cultivo generalmente facilita su mejor crecimiento.

3.2 Instalaciones

Las instalaciones que se utilizaron (hasta la fecha) en los experimentos con el cultivo de los ostiones del mangle son las siguientes:

3.2.1 Instalaciones para colectores y cultivos colgantes

Están compuestos por estacadas en línea (Fig. 4) u en forma rectangular, emergiendo de la superficie marina aproximadamente de 1 a 1,5 m con travesaños sobre los cuales se suspenden los colectores y los cultivos, e

3.2.2 Instalaciones para colectores y cultivos tendidos

Son estacadas rectangulares donde los travesaños son varas que sirven como colectores colocadas a nivel intermedio del eulitoral; pisos (camas) artificiales construidos también al mismo nivel para colocar colectores o albergar ostiones esparcidos (Fig. 4) y corales con igual propósito (Fig. 5).

Estas instalaciones son aplicables en áreas con fondos lodosos (fangosos).

3.3 Colectores

Se realizaron experimentos con diferentes tipos de colectores confeccionados de distintos materiales; varias maderas (mangle rojo, mangle prieto, caña brava, palma real, caña de castilla, etc.); valvas de ostiones; placas de fibrocemento, tejas de barro y cartones moldeados para guardar huevos.

Los mejores resultados se obtuvieron con los siguientes tipos de colectores: rama de mangle rojo con 5 y hasta 10 ramificaciones, colgante y 40-70 cm de longitud total (40 - 701 ostiones); "collar" o sarta colgante con 20 hasta 200 valvas (46 - 632 ostiones); cesto, hecho de tela metálica galvanizada, tendido 90 x 30 cm con aproximadamente 200 valvas (120 - 1 405 ostiones); 3 cartones moldeados, protegidos por tela metálica galvanizada, tendidos 90 x 30 cm (2 730 - 3 543 ostiones). Actualmente se realizan experimentos con varas (cujes) de mangle rojo de 5 cm de espesor tendidas con resultados satisfactorios.

3.4 Los cultivos y su explotación

A los cultivos pertenecen ostiones menores desprendidos casualmente o intencionalmente de su substrato y esparcidos sobre pisos artificialmente preparados. El principal propósito es de llevarlos con las menores pérdidas posibles, a los tamaños comerciales teniendo en cuenta también su calidad. Dentro de los cultivos se pueden considerar también los colectores con ostiones adheridos y trasladados del área de fijación a instalaciones ostrícolas donde se les puede dar debida atención.

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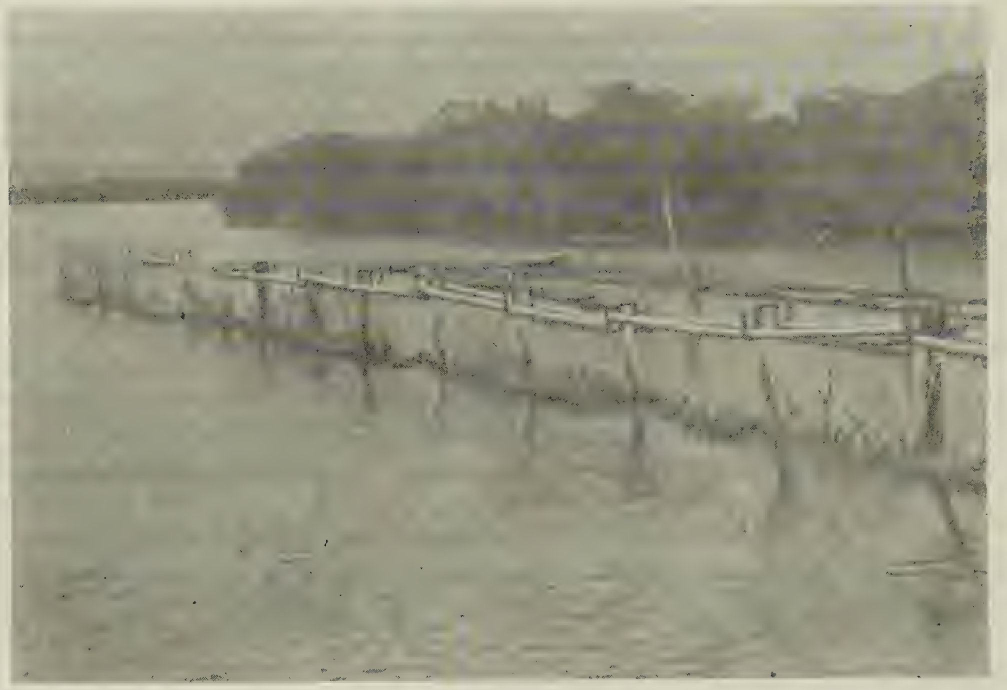

Fig. 4 Estacada en línea con colectores y cultivos colgantes (en primer plano); cajas ostrófilas cubiertas con hojas de palma real colocadas sobre un piso artificial (detrás)

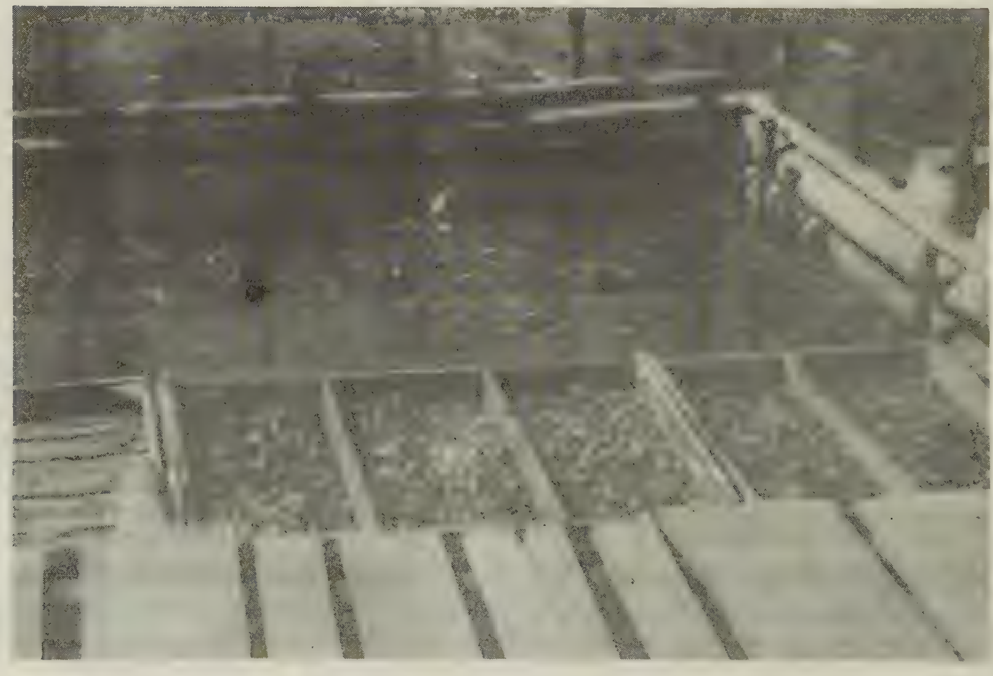

Fig. 5 Un corral con cajas ostrófilas (conteniendo ostiones) colocados sobre troncos de yuraguana que yacen sobre el piso lodoso, algo endurecido con valvas de ostiones

Los experimentos realizados al respecto dieron los siguientes resultados:

Los ostiones adheridos - La rama de mangle rojo dió los mejores resultados como colector tipo. Su obtención y confección requiere un trabajo mínimo, su utilidad es aproximadamente de un año y su rendimiento es relativamente muy alto. Además tiene la ventaja de que los ostiones adheridos se desprenden con más facilidad que de otras maderas. Es por eso un tipo de colector con alto valor en áreas que tienen aguas sin grandes movimientos. La primera explotación de dicho colector se puede realizar después de 3 o 4 meses siempre durante la marea baja, o sea, cuando los ostiones están fuera del mar lo que permite observar la recogida, impedir separaciones indeseadas y al mismo tiempo realizar limpieza de organismos asociados sin producir daño a los ostiones frágiles de menor tamaño. Recolectas subsiguientes pueden realizarse cada 30 o 60 días consecutivos (Fig. 6). Estudios realizados al respecto sobre los colectores de 7 meses de edad (marzo - septiembre 1968 en Casilda) proporcionaron los siguientes resultados para cada colector: entre 210 ostiones vivos presentes, con un peso total 1 214 gr, había un 39,5 por ciento de tamaño comercial. La distribución de tamaños era entre 2 y 89 mm con clases modales 17, 29, 41 y 59. El porcentaje de ostiones muertos encontrados era mayor entre los individuos menores de 50 mm: 9,8 por ciento, mientras que entre los mayores alcanzó solamente el 0,4 por ciento. El 39,5 por ciento de ostiones comerciales es considerado demasiado elevado ya que éstos por su peso, al producirse un oleaje algo fuerte, pueden desprenderse y caer sobre el fondo fangoso.

Por este motivo deben revisarse los colectores frecuentemente para evitar pérdidas innecesarias.

Los ostiones cementados a varas cuadrangulares de madera o sobre placas de fibrocemento dieron resultados satisfactorios pero por el tiempo invertido en la labor de cementación, este procedimiento resultó costoso e inadecuado. Además, los tamaños alcanzados por los ostiones y el porcentaje de los muertos encontrados eran similares a aquellos adheridos a los colectores de ramas del mangle.

En el caso de los ostiones esparcidos directamente sobre pisos artificialmente preparados o en cajas ostrófilas se presentan los siguientes problemas principales. Cuando se realiza la separación del substrato (corteza del mangle rojo o valva de un otro ostión) se produce cierta lesión de la concha que en algunos casos es irreparable. Esto sucede debido a que el área de fijación está en la parte anterior de la valva izquierda donde la posibilidad de regeneración es mucho menor. Los que sobreviven a esta operación, al esparcirlos sobre fondos artificiales, se enfrentan con un nuevo modo de vida, lo que les proporciona otras inconveniencias. Si no están bien distribuidos por compartimientos, con el tiempo y por efecto de las olas los ostiones se amontonan y al chocar entre sí lesionan sus conchas. Las acumulaciones del lodo son mucho mayores que sobre los ostiones adheridos a las ramas del mangle.

4 CONCLUSIONES Y RECOMENDACIONES

La composición por tamaños de poblaciones de ostiones del mangle varía por áreas y/o temporadas. Ejemplos típicos son: 2 - 23 mm (Mo = 2), 2 - 56 mm (Mo = 11, 26 y 41), 2 - 83 mm (Mo = 11, 23, 32, 41, 53, 62 y 71).

En el habitat natural no explotado hay hasta un 86,9 por ciento de excedentes disponibles para la recolección (explotación); en áreas explotadas este número varía entre 1.6 y 35.8 por ciento.

La cantidad de excedentes disponibles es siempre mayor que el número de ostiones recolectados. La composición por tamaños en las recogidas actuales varía entre 5 y 83 mm de los cuales hay solamente entre 28,2 y 34,8 por ciento mayores de 50 milímetros.

El crecimiento es relativamente rápido debido a que el ostión alcanza su tamaño comercial (50 mm) entre los 5 y 7 meses de edad.

La mortalidad es mayor entre los de tamaños menores y menor entre los ostiones que sobrepasaron los 50 milímetros. La mortalidad encontrada varía entre 5 y 10 por ciento pero en una oportunidad alcanzó hasta 19,1 por ciento. Hay un porcentaje todavía no establecido de ostiones que desaparecen de las existencias por separación indeseada debido a sus pesos excesivos, a causa de enemigos naturales y por una recolección irracional.

Al evitar la recolección indiscriminada, el corte de mangle y la contaminación de las áreas ostioneras, no es necesario introducir ninguna medida de conservación en el recurso-ostión. Pero es conveniente organizar un control biológico de organismos asociados y especialmente de los enemigos del ostión.

Existen posibilidades para desarrollar el cultivo artificial de ostiones del mangle aunque todavía es necesario resolver varios problemas. Entre los mejores colectores figuran las ramas de mangle rojo (colgadas y tendidas) que dieron el más alto rendimiento con muy bajo costo de adquisición y confección.

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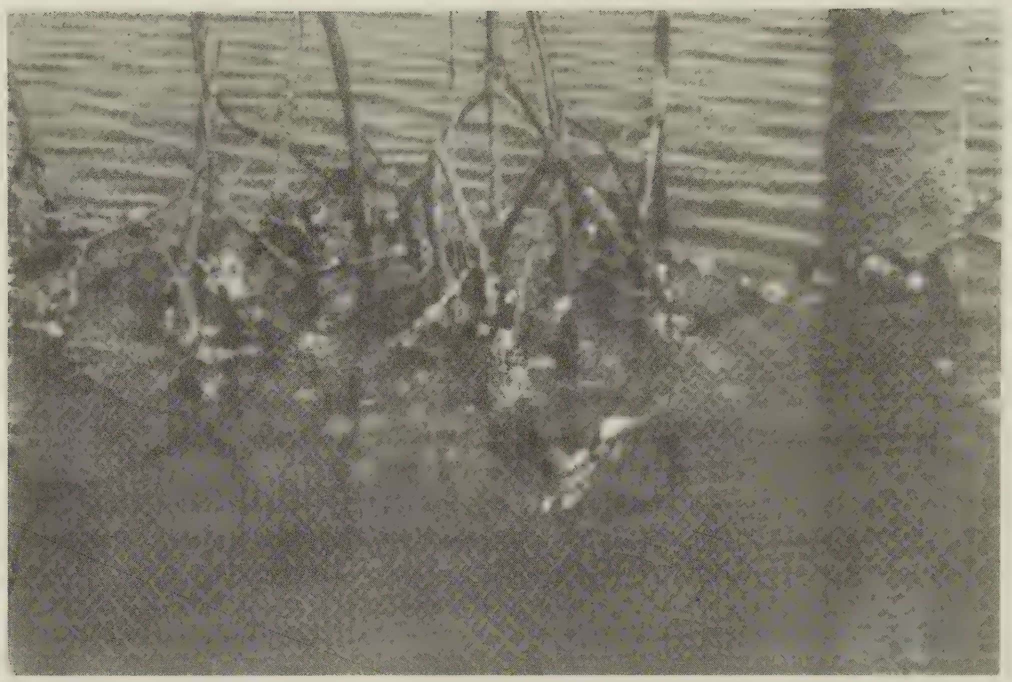

Fig. 6 Colectores tipo rama de mangle rojo colocados en instalaciones ostricolas tipo estacadas rectangulares

No hay diferencias en lo que al crecimiento se refiere entre los ostiones del habitat e individuos adheridos sobre colectores. Sin embargo, el porcentaje de ostiones muertos varía y depende de la habilidad del cultivador durante las labores de separación (individualización) y limpieza, así como de los enemigos naturales.

Se debe dar énfasis a las investigaciones sobre el aprovechamiento total de ostiones menores, la influencia de organismos asociados y las condiciones ecológicas, así como sobre el mejoramiento de la calidad de los ostiones cultivados.

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NOTAS BIOLOGICO-PESQUERAS SOBRE EL CAMARON BLANCO
Penaeus schmitti Burkenroad 1936

por

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1 INTRODUCCION

Sobre la base de investigaciones precedentes de Nikolić y Ruiz de Quevedo (1967) se seleccionó el área de Tunas de Zaza, provincia de Las Villas, en la plataforma suroriental de Cuba, para continuar los estudios biológico-pesqueros sobre camarón blanco iniciados por los investigadores mencionados.

El objetivo principal de este trabajo es la interpretación del ciclo gonadal del camarón blanco y la relación de estas observaciones con datos de producción de la zona.

Se agradece la cooperación prestada por los pescadores de Casilda y Tunas de Zaza, Las Villas, en los muestreos así como la valiosa ayuda del señor Genovevo Protillo Vergel. Agradecemos igualmente a la Srta. Alina Alvarez, por la preparación de los dibujos de este trabajo.

2 MATERIALES Y METODOS

Se realizaron muestreos mensuales a bordo de embarcaciones arrastreras con una ó dos redes que operan en la zona escogida para la ejecución del trabajo. El trabajo práctico consistió en obtener por un método aleatorio simple 100 a 200 ejemplares en cada estación de muestreo (Cuadro I). En todos los ejemplares estudiados (n = 5 247), se midió la longitud total (mm) y la longitud de cefalotórax (mm); se determinó el sexo y el número de hembras impregnadas; se observó la textura del exoesqueleto; se anotó, en base a un método elaborado por nosotros, el aspecto y color de los ovarios.

Se determinaron cinco estadios gonadales (Cuadro II).

Se relacionó la variación macroscópica de los ovarios con el aspecto microscópico, tomando como la base los datos obtenidos por King 1948, Angelescu y Boschi 1959, Cummings y Olguín 1967. Las hembras clasificadas según este método se agruparon en clases milimétricas con una variación en cada clase de 10 mm, con el objeto de establecer la correlación de los diferentes estadios gonadales, con las longitudes totales. La clase menor es la V (50-59 mm) y la mayor observada es la XII (120-129 mm).
El estudio de estas características se hizo por estaciones anuales.

Una de las fuentes de información utilizadas para el análisis de la producción camaronera de la zona, fue la Cooperativa de Pescadores "Capitán Ernesto Valdés Muñoz" de Tunas de Zaza. Se elaboraron datos proporcionados por colectores del Centro de Investigaciones Pesqueras, relacionados con nuestro tema.

CUADRO I

Datos sobre el muestreo
Area pesquera de Tunas de Zaza, Las Villas

Fecha	Embarcación	Colector	Estado de los camarones	Arrastre	No. de ejemplares muestreados
X-/67	CAMARON I	F. Rodríguez	Cons. en Formol 10%	Diurno	307
XI-/67	"	"	"	Nocturno	298
XII-/67	C. CAMILO	"	"	"	300
II-/68	CAREY	F. Rodríguez G. Portillo	"	"	400
III/68	"	"	Fresco	Diurno	500
IV/68	CARDENAS XVI	"	"	Nocturno	596
V/68	"	G. Portillo	Cons. en Formol 10%	Diurno	600
VI/68	"	"	"	Nocturno	546
VII/68	"	F. Rodríguez G. Portillo	Fresco	"	500
VIII/68	CHOPA	"	"	"	600
IX/68	CAREY	"	"	Diurno	600

CUADRO II

Denominación de los estadios gonadales adoptados

Estadio	Aspecto	Color
1	Sin gónada desarrollada	
2	Filiforme	Transparente
3	Acintado	Blanco
4	Poliédrico	Amarillo
5	Poliédrico	Anaranjado

3 AREAS DE PESCA

La zona investigada comprende a Tunas de Zaza y aguas adyacentes; el río Zaza también interviene con sus caudales en el sistema biológico observado. Se establecieron tres estaciones de muestreo; su situación geográfica se muestra en el Cuadro III.

Las áreas pesqueras que circundan a nuestras estaciones están señaladas en la Figura 1; se adoptó el sistema de cuadrículas de Nikolić y García 1967, para denominar tanto a nuestras estaciones de muestreo, como a las áreas de pesca vecinas.

Se consideró como área de pesca 1, a las cuadrículas JI-18, KI-19 y KI-18; esta última es nuestra estación 1. Se extiende desde el río Tallabacoa hasta Punta Ladrillo. Según nuestros datos, esta área tiene sus mayores capturas camaroneras en otoño.

El área de pesca 2, está constituida por las cuadrículas LI-21, MI-21 y KI-21, y en esta última se encuentra nuestra estación de muestreo 2. Los limites de esta área son Punta Ladrillo y Punta Tolete. La información disponible demuestra que las capturas en esta área son mayores en invierno.

Denominamos como área de pesca 3, a las cuadrículas NI-20 y LI-20; esta última es nuestra estación 3; su localización corresponde a la desembocadura del río.

Según nuestros datos, esta área, como la anterior, produce sus mayores capturas en el invierno.

4 RESULTADOS

4.1 Distribución de los camarones de importancia comercial en el área

En la primavera las tres estaciones de muestreo presentan como especie dominante al camarón acaramelado; en verano y otoño se registran en ambas estaciones de muestreo una proporción mayor de camarón blanco en nuestras capturas. Durante el invierno, la especie dominante es el camarón blanco, en las estaciones 1 y 3, mientras que el acaramelado es, en este período, más abundante en la estación 2.

4.2 El camarón blanco - sus características biológico-pesqueras

Primavera (de marzo a mayo)

Las hembras predominan en las estaciones 2 y 3 y el porcentaje de hembras recién mudadas es mayor también, con respecto al de los machos muestreados. En la estación 1 los machos son más abundantes, y el porcentaje de machos recién mudados es mayor también.

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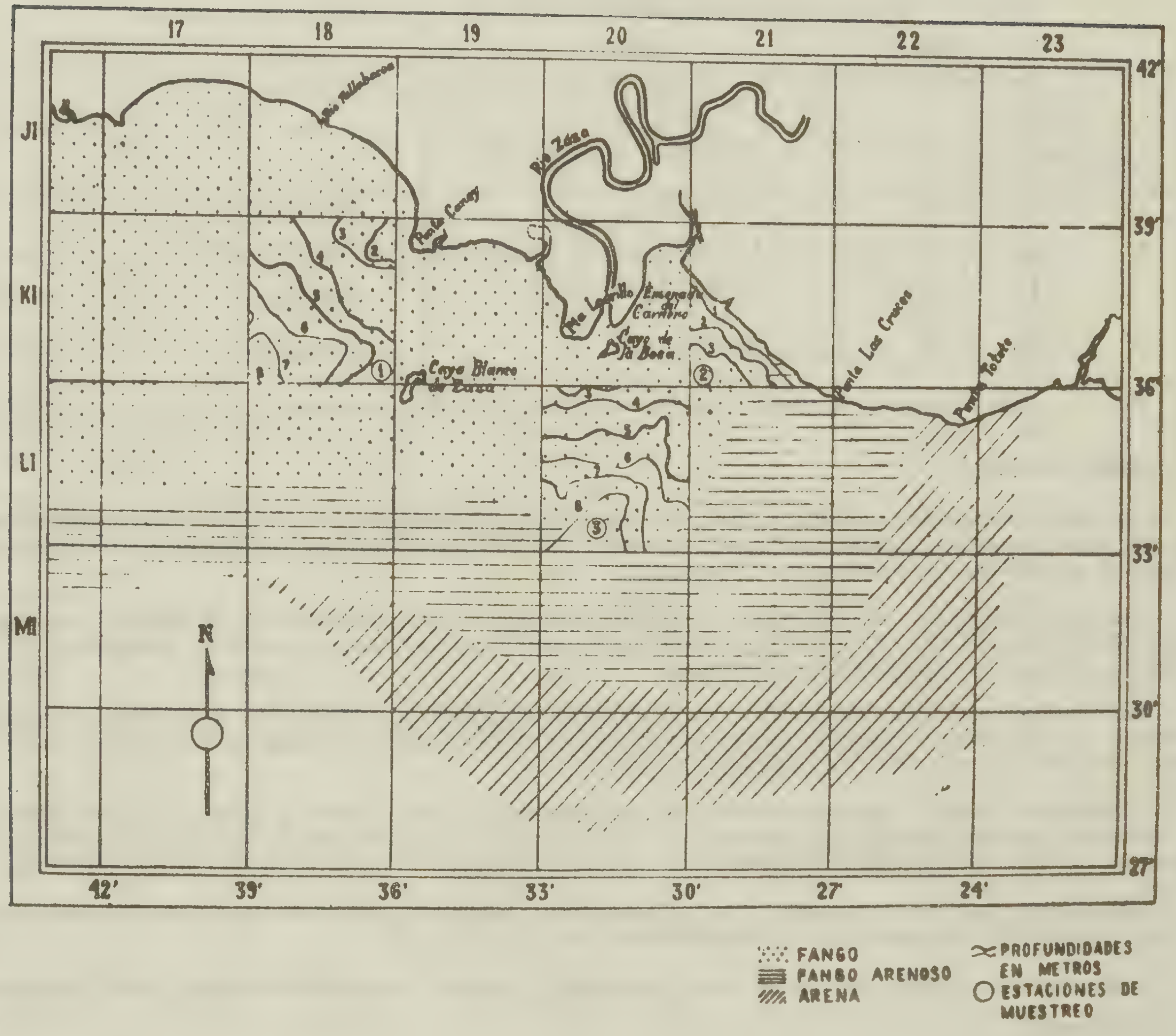
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Cayo de la Boca
Cayo Blanco de Zaza
Punta Las Cruces
Punta Tolete
①
②
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N
FANGO
FANGO ARENOSO
ARENA
PROFUNDIDADES EN METROS
ESTACIONES DE MUESTREO

Fig. 1 Ubicación geográfica de las estaciones de muestreo (Tunas de Zaza, Las Villas)

CUADRO III

Algunas características geográficas y ecológicas
de las estaciones de muestreo

Características	Estación 1	Estación 2	Estación 3
Latitud	21°36'-21°39'		21°33'-21°36'
Longitud	79°36'-79°39'		79°30'-79°33'
Superf. tot. millas nauticas2	9	2.6	9
Distancia del río en millas	5.8	3	3
Distancia de los cayos (millas)	2.7	6.2	4.5
Tipo de fondo	Fango grís oscuro	Fango grís oscuro	Fango grís oscuro
Prof. prom (m)	10	3.6	10
Temperatura ambiental media anual (°C)	25.3	24.6	24.6

En este lapso trimestral, las hembras son más grandes que los machos, en toda la zona. La variación en clases milimétricas de talla, para las hembras, comprende desde la clase VIII, hasta la XII. Los reclutas corresponden a la clase X.

En toda el área, para este período anual, dominan los estadios gonadales "acintado blanco" y "poliédrico anaranjado" (Figura 2).

Verano (de junio a agosto)

En las tres estaciones de muestreo el porcentaje total de hembras, y de hembras recién mudadas, es mayor que aquel de machos. Sólo en junio se presentan hembras de mayor talla que los machos; durante los dos meses restantes, los ejemplares de ambos sexos corresponden a las clases VII y VIII. Los reclutas pertenecen a la clase VII. Los estadios gonadales predominantes son "filiforme transparente" y "poliédrico amarillo" (Figura 2).

Otoño (de septiembre a noviembre)

Las hembras dominan en las estaciones 1 y 3; el mayor porcentaje de hembras recién mudadas aparece en la estación 1. En las estaciones 2 y 3 la mayor cantidad de ejemplares recién mudados corresponde a los machos. Solamente en dos meses, septiembre y noviembre, las hembras son más grandes que los machos en la estación 3, mientras que las otras dos estaciones, los dos sexos se distribuyen en las mismas clases milimétricas. En las estaciones 2 y 3 aparecen hembras impregnadas.

En este período se observan ejemplares pertenecientes a las mismas clases de tamaño que en el verano. Los reclutas corresponden a la clase VIII.

Además, en toda el área se observan gónadas en el estadio "filiforme transparente" y en el estadio "poliédrico amarillo"; en la estación 2 se encuentra además el estadio "acintado blanco".

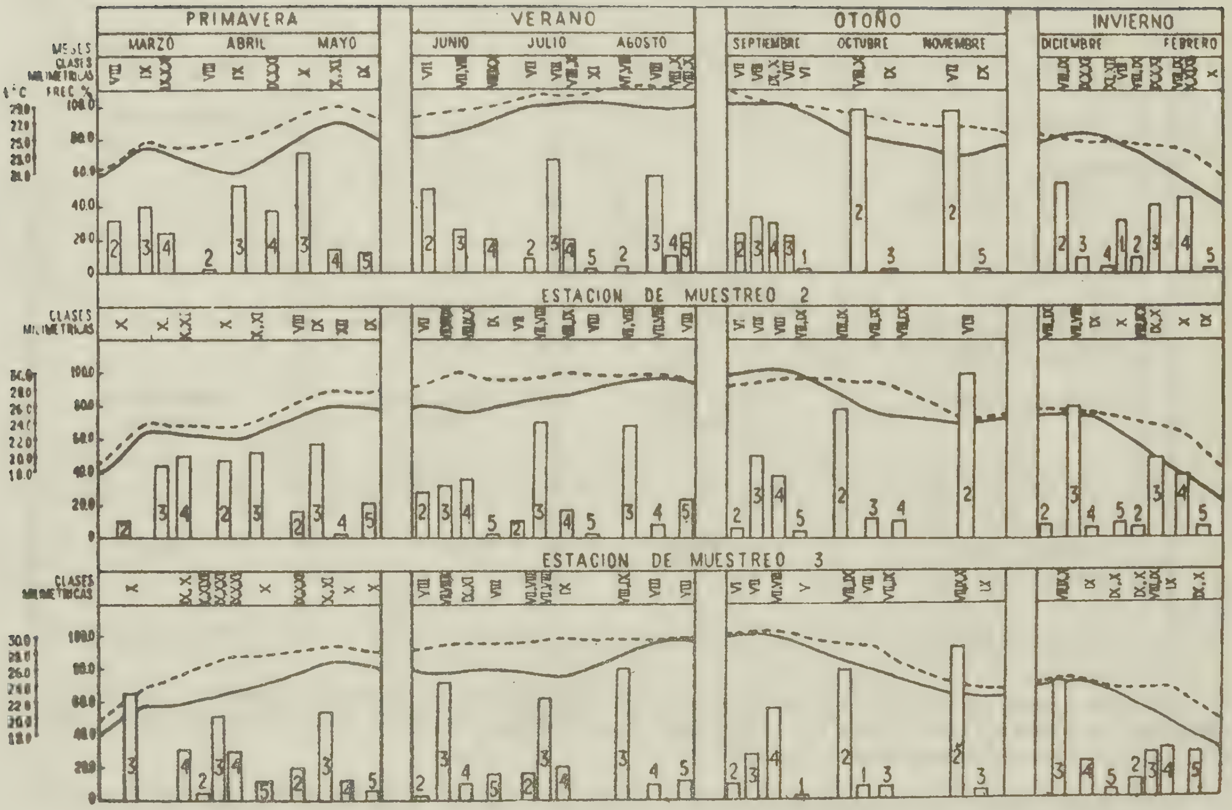

Fig. 2 Ciclo gonadal en las hembras de Penaeus schmitti, según frecuencias de clases de longitud total y estaciones del ano, en la región de Tunas de Zaza, Las Villas, temporada 1967-68 (Clave: 1 = sin gonada desarrollada; 2 = gonada transparente de aspecto filiforme; 3 = gonada acintada de color blanco; 4 = gonada poliédrica de color amarillo; 5 = gonada poliédrica de color anaranjado; —— t°C = temperatura ambiental; - - - t°C = temperatura del fondo)

Invierno (de diciembre a febrero)

En la estación 2 predominan las hembras, y en las estaciones 1 y 3, los machos. En toda el área las hembras recién mudadas dominan en las muestras. Durante diciembre y febrero las hembras en las estaciones 2 y 3 son más grandes que los machos. En la estación 1, los ejemplares de ambos sexos pertenecen a las mismas clases de tamaño.

La variación de tamaños observada dentro del área, comprende a ejemplares que se distribuyen desde la clase VII hasta la X. Los reclutas corresponden a la clase X.

En la estación 1 se registró como predominante el estadio "filiforme transparente"; los estadios "acintado blanco" y el "poliédrico amarillo se encuentran en toda el área.

Según datos de 1961 a 1968, las capturas totales de camarones comerciales desembarcados en nuestra zona, aumentan en poco más de 100 toneladas por año. Esta evolución, junta con los estadios gonadales más representativos, y con las tallas dominantes, se presenta en la Figura 3.

Los resultados de un análisis de la actividad pesquera del buque arrastrero SIBONEY demuestran que la pesca se puede realizar durante todo el año. Se sabe que desde junio hasta noviembre, esta embarcación durante los dos temporadas analizadas, logró rendimientos sostenidos y mejores que otras de su tipo.

Hay una interrelación entre los valores máximos y mínimos de las capturas desembarcadas en Tunas de Zaza, y las temperaturas registradas en la zona durante la primavera y el verano y lo mismo puede observarse en el caso del régimen fluvial del Río Zaza. Tal como la mencionan Gunter y Hildebrand (1954) y otros, las fluctuaciones en las capturas pueden deberse a factores ecológicos, climatológicos, etc.

5 DISCUSION

El camarón blanco durante la primavera está menos representado que el camarón acaramelado en el área estudiada.

Los movimientos que efectúan los camarones obedecen fundamentalmente a la necesidad de realizar sus funciones reproductoras en áreas diferentes a la que ocupan cuando son juveniles. Esto es también el caso en las especies que nos interesan. Ewald (1964), establece que "la época de reproducción más intensiva corresponde a los meses del segundo trimestre del año". Este dato coincide con las observaciones nuestras. Nosotros encontramos que las hembras de tallas mayores se registran a principios de la primavera - marzo. Según Iversen y Jones (1961), "hay una aparente y pequeña diferencia entre el crecimiento de invierno y de verano".

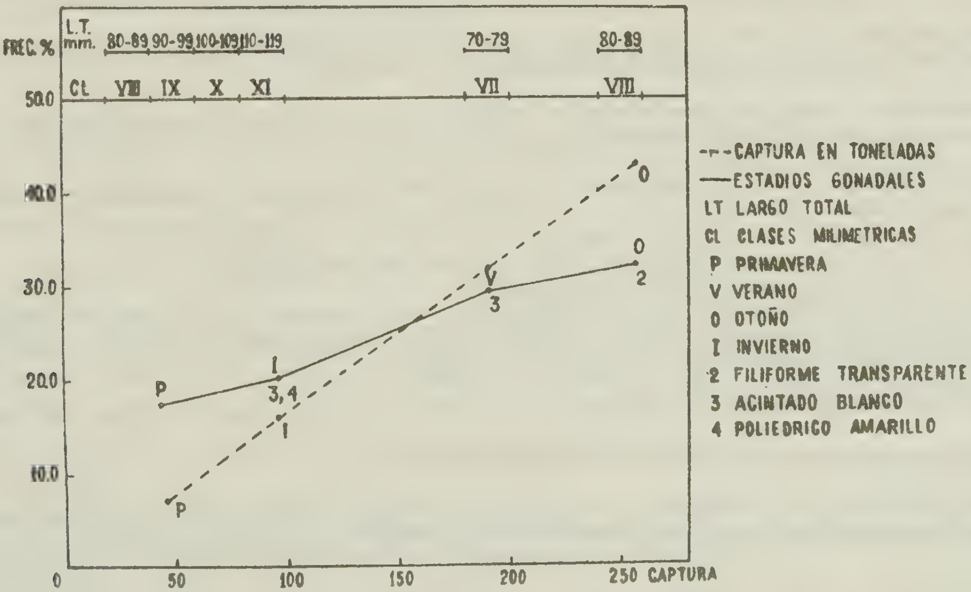

Fig. 3 Relación entre capturas y estadios gonadales representativos en las hembras de Penaeus schmitti, para las temporadas 1966-67-68, región Tunas de Zaza, Las Villas

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Iversen (1959) determinó que "hay un aumento general en el tamaño promedio del camarón con el incremento en la profundidad de las aguas".

Según Carles (1967) hay una variación en temperatura de aproximadamente 7ºC durante el invierno en la zona de aguas protegidas de Tunas de Zaza. En el verano esta diferencia térmica es de unos 3ºC. Nuestros datos nos indican que durante el invierno, los ovarios de las hembras de P. schmitti no evolucionan al mismo ritmo que durante el verano. Esto se debe a que se registran temperaturas bajas, tanto en el mar como en los esteros (zonas de crecimiento y nutrición).

La temperatura es uno de los factores físicos que influyen directamente en los procesos de maduración gonadal y de desove; Cummings (1961), Eldred (1961) y otros establecen la relación entre las épocas de desove masivo y temperaturas máximas.

Ewald (1965) y Joyce (1965) determinan que la salinidad en cambio no es un factor que influye en los desoves de los camarones.

De nuestra información elaborada, y de datos proporcionados por los camaroneros de la región, se desprende que hay dos períodos de desove, uno a principios de la primavera y otro en agosto. Como durante el verano se observan las clases de talla mas pequeñas en toda el área, podemos inferir que a finales de la primavera y del verano P. schmitti realiza desoves masivos. En los primeros meses del otoño se registra una cantidad abundante de preadultos, lo que comprueba un desove precedente.

En verano, la predominancia de las hembras sobre los machos puede interpretarse como factor favorable para el incremento del desove, para el cual las condiciones ambientales son menos favorables en otros períodos.

El estadio gonadal dominante durante la primavera y el verano es el "acintado blanco", lo que corresponde a un mínimo para los estadios "filiforme transparente", "poliédrico amarillo" y "poliédrico anaranjado". A medida que avanza el otoño, el estadio "filiforme transparente" pasa a ocupar un lugar dominante en el área; se registran entonces los valores mínimos en los estadios "acintado blanco" y "poliédrico anaranjado". Esto demuestra que las áreas de desove y las de decrecimiento de los preadultos no son las mismas, y que tampoco coexisten en el mismo habitat, generaciones de hembras maduras, y ejemplares en vías de maduración.

En el invierno no se observan características homogéneas en toda el área. En las estaciones 2 y 3 los ovarios de las hembras analizadas se presentan en el estadio "acintado blanco", pero como ya se dijo, hay también un grupo de hembras maduras, que desovan a principios de la primavera.

6 CONCLUSIONES Y RECOMENDACIONES

1. El método elaborado para determinar y diferenciar macroscópicamente a los diferentes estadios de madurez de las gónadas femeninas en P. schmitti, es aceptable.

2. Las dos especies de camarones comerciales de la zona "Tunas de Zaza" no están presentes, en la misma proporción, durante todas las estaciones del año.

3. Para el camarón blanco se registran máximos de abundancia de hembras y mínimos de machos en invierno y primavera.

4. En verano y en otoño, la proporción de los sexos es aproximadamente 1:1.

5. Durante la primavera las hembras son aproximadamente 10 mm mayores en talla que los machos. Esta diferencia de tamaños disminuye paulatinamente, desde el verano hasta el invierno, períodos en los cuales los dos sexos muestran tallas muy semejantes.

6. Como épocas de desoves masivos se señalan el principio de la primavera y el final del verano.

7. El verano es un período de crecimiento de preadultos.

8. En el otoño se señala un reclutamiento masivo con predominio de individuos preadultos (con gónadas filiformes-transparentes) que salen de los esteros al mar.

9. Se demuestra que la temperatura del área influye en el desarrollo de la gónada, acelerando su proceso evolutivo durante los meses cálidos y manteniendo un desarrollo celular lento, durante el período de temperaturas bajas.

10. Las tallas mayores (adultos) se registran en la primavera y las tallas menores en el verano.

11. A un máximo del estadio "filiforme transparente", corresponde un mínimo de los estadios "acintado blanco", y "poliédrico anaranjado".

12. En base a los establecido en los puntos 10 y 11, se sugiere que la pesca sea limitada a ejemplares mayores de 80 mm (largo total), que las actividades arrastreras y atarrayeras sean disminuidas durante los meses de octubre y noviembre, pudiendo incrementarse más los arrastres durante los meses de primavera.

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LOS RECURSOS PESQUEROS DEL NORDESTE DE SUDAMERICA

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1 INTRODUCCION

Consideramos área pesquera del nordeste de Sudamérica la comprendida frente a las costas que se extienden desde el Cabo São Roque (Brasil) hasta el Golfo de Paria y Trinidad. Estas costas poseen una extensión de perímetro envolvente de 3 407 km y la anchura de la plataforma es muy variable: frente al Estado de Rio Grande do Norte es de unos 30 km; frente al Estado de Ceará, 50 km; frente al Río Parnaíba, 170 km; frente al Cabo Norte y Cabo Orange, 300 y 200 km, respectivamente; frente a las Guayanas, 150 km. La área total de la plataforma es de unos 540 000 km^2.

El área se caracteriza ecologicamente por el aporte de aguas dulces provenientes de grandes ríos: Parnaíba, Amazonas, Surinam, Esequibo, Orinoco y por el arrastre de estas aguas en dirección noroeste, debido a las corrientes Nor e Sur Ecuatorial. Estas similares características ecológicas hacen que la fauna a lo largo de toda la costa sea la misma, o al menos sin ninguna variación notable, y que toda el área en conjunto pueda considerarse como una unidad desde el punto de vista de la pesquería. No obstante, por razones de orden práctico y a fin de clarificar la exposición, dividimos esta área en tres regiones: nordeste del Brasil, desde el Cabo São Roque hasta la desembocadura del Río Parnaíba; norte del Brasil, desde la desembocadura del Río Parnaíba hasta el Cabo Orange; Guayanas, desde el Cabo Orange hasta el Golfo de Paria y Trinidad.

2 RECURSOS PESQUEROS

Atendiendo a las características ecológicas de los recursos pesqueros, los podemos dividir en oceánicos, costeros y estuarinos.

Los recursos pesqueros oceánicos están representados principalmente por los atunes y entre éstos tienen especial importancia el atún aleta amarilla (*Thunnus albacares*) al norte del Ecuador y la albacora (*Thunnus alalunga*) al sur de esta línea. Se han obtenido rendimientos de 4 a 6 toneladas por 2 000 anzuelos de albacora y de 10 a 14 toneladas de atún aleta amarilla. La distribución de estas dos especies sugiere que se encuentran en estrecha relación con las corrientes ecuatoriales (Nakamura *et al.*, 1963). Según Jarov (1966), la concentración de atunes está condicionada por la presencia de zonas frontales en que convergen masas de agua de baja temperatura y alto contenido en nutrientes inorgánicos, con aguas de temperaturas más elevadas. En estas zonas de frontera se dan condiciones favorables para el desarrollo de la vida orgánica. Asi pués, las necesidades de nutrición son el factor principal que impulsan a los atunes a reunirse en determinadas áreas. Estas condiciones se dan en la zona de bifurcación de la corriente Sur Ecuatorial en la de Guayanas y de Brasil.

En el nordeste de Sudamérica existen dos períodos principales para la pesca de atunes: el de primavera y el de otoño-invierno.

En 1956 solamente existían 136 mil anzuelos en operación en el Atlántico, de ellos 81 mil en el área que consideramos. En 1962, el esfuerzo total era de 54 millones de anzuelos, de ellos correspondían más de millones a nuestra área. En 1964 el esfuerzo total era de casi 85 millones de anzuelos, de ellos más de 7 millones frente a las costas del nordeste de Sudamérica.

La característica más notable es el agudo declive de las capturas para el atún aleta amarilla, que pasó por un promedio de 7 a 9 peces por 100 anzuelos en el período 1956-58 a menos de 2 ejemplares por 100 anzuelos en 1962, lo que significa una caída de 7 toneladas por día de pesca a 1/2 tonelada. Esto podría ser debido a una disminución de la población o a una traslación de los lugares de pesca (Shomura, 1966). Según Wise (1968), el decrecimiento de las capturas de esta especie fué debido a haber sobrepasado la pesca el potencial de la especie, que este autor estima en unos 550 mil ejemplares anuales para las áreas del Golfo de Guinea y nordeste de Sudamérica, que son consideradas las más productivas.

Las capturas totales de albacora en el Atlántico mantuvieron un alza constante hasta el año 1964. El número de ejemplares de esta especie por cada 100 anzuelos en el área del nordeste de Sudamérica se ha mantenido prácticamente constante entre 1957 y 1964 inclusive.

En el Atlántico Tropical la captura de atunes en 1957 fué de 15 mil toneladas, cantidad que fué creciendo gradualmente hasta alcanzarse la cifra de 95 mil toneladas en 1962, estabilizándose posteriormente en algo más de 100 mil toneladas (Idyll, 1966).

En el puerto de Recife (Brasil) se desembarcaron 4 500 toneladas de atunes en los años 1961-62, 1 203 toneladas en 1963 y 697 toneladas en 1964. Los desembarcos fueron disminuyendo gradualmente a partir de 1961 y las causas son variadas, pero han sido más definitivas las de orden socio-politico que las debidas a una disminución de la productividad.

En Venezuela, se desembarcaron 2 000 toneladas de atunes en 1960, 2 010 toneladas en 1961, 3 540 toneladas en 1962, 3 090 toneladas en 1963 y 1 920 toneladas en 1964. Aunque estos desembarcos incluyen tanto el área del Caribe como la Atlántica, se observa también un decenso gradual de los desembarcos, que no se puede achacar a problemas extraños a la actividad pesquera en sí.

Los peces voladores son capturados frente al litoral del Estado de Rio Grande do Norte, especialmente en los meses de Marzo a Julio. Aunque la pesca se efectúa cerca de la costa, el recurso en sí puede considerarse oceánico. La producción es muy pequeña y en 1965 fué de 73 toneladas.

Los recursos pesqueros costeros son mucho más variados que los oceánicos y se encuentran más específicamente vinculados a determinadas regiones o tipos de fondos. Su explotación también se encuentra condicionada por la estructura de la pesquería, su capacidad y las exigencias de los mercados locales o externos.

2.1 Región del nordeste de Brasil

La plataforma continental en este tramo es considerablemente estrecha.

No hay propiamente fondos fangosos y solamente una estrecha franja arenosa. En èsta zona se capturan Sciaenidae, principalmente de los géneros Cynoscion, Macrodon y Micropogon, que tiene una importancia a lo sumo local, no existiendo ninguna pesquería industrial para estas especies que por otra parte no parece tampoco que ofrezcan grandes perspectivas.

En los fondos rocosos de esta región existen especies de extraordinaria importancia comercial: el pargo o cioba y las langostas.

El pargo o cioba (Lutjanus purpureus) se pesca con palangre de fondo y anzuelos. Son utilizadas embarcaciones de 17 a 30 m por término medio, con capacidad de 20 a 30 toneladas, aunque también hay embarcaciones con capacidad hasta de 160-170 toneladas. La explotación de este recurso comenzó intermitentemente en 1961, en 1965 la producción fué de 2 300 toneladas. Todo parece indicar que la tendencia positiva de la producción podría incrementarse y que es posible encontrar nuevos caladeros.

De las langostas son capturadas las especies *Panulirus argus* y *Panulirus laevicauda*, correspondiend más del 60 por ciento a la primera especie. La producción de langostas creció aceleradamente desde 1955, en que se exportaron 40 toneladas de colas congeladas hasta 1962 en que se exportaron el total de 1 382 toneladas, decreciendo después paulatinamente hasta 1966, en que la producción fué inferior a la de 1961. El descenso de las capturas parece ser debido principalmente a la reducción del esfuerzo total de pesca, por la eliminación de las embarcaciones de características pesqueras primitivas, y a la concentración del esfuerzo en un área geográfica menor a causa del gran número de nasas utilizadas por las embarcaciones grandes (Paiva, 1967).

De tipo artesanal, existe una pesquería de peces pelágicos costeros, entre estos se destacan por su importancia los carites (*Scomberomorus cavalla* y *Scomberomorus maculatus*), que se pescan con anzuelo.

2.2 Región del norte de Brasil

La plataforma continental es muy amplia, en virtud de la desembocadura de los Ríos Parnaíba y Amazonas, principalmente el segundo. Los recursos demersales en esta región son poco conocidos.

Entre los peces, los bagres constituyen el recurso más importante de los fondos fangosos, y se encuentra también las corvinas y el roncador (*Micropogon furnieri*), pero existen pocos datos sobre la abundancia y rendimiento comercial de los mismos.

Actualmente el recurso más importante de los fondos fangosos lo constituyen los camarones del género *Penaeus*, frente a la desembocadura del Río Amazonas. En frente al Estado de Maranhão más de la mitad de la producción camaronera corresponde a la especie seis barbas (*Xiphopenaeus kröyeri*) y las mayores capturas se hacen en los meses de mayo a octubre.

En los fondos rocosos el más importante recurso es el pargo o cioba. Las primeras tentativas de explotación industrial de esta especie se comenzó en 1961, obteniendose buenos resultados.

De tipo artesanal, hay una pesquería de cazones cerca de la costa, que se capturan principalmente de mayo a agosto, con redes y anzuelos.

2.3 Región de las Guayanas

La plataforma continental es relativamente amplia, en virtud del aporte de sedimentos de sus grandes ríos.

Los recursos más importantes de los fondos fangosos son las corvinas y los camarones.

La corvina *Cynoscion virescens* es la especie que ofrece mejores perspectivas de explotación; se encuentra a lo largo de toda la región en fondos de 3 a 22 brazas y sua abundancia llega a un rendimiento máximo frente a las costas de el Surinam (Ginés y Cervigón, 1968). Es un recurso poco explotado, que prácticamente no se aprovecha ni a nivel local.

Otra especie comercial abundante en los fondos fangosos es el roncador, aunque su importancia es mucho menor que la de las corvinas. También se capturan en estos fondos cazones y rayas, bagres, *Anchoa spinifer* y otros Engraulidae, pequeños Clupeidae de los géneros *Pellona* y *Harengula*, peces que actualmente no se aprovechan y que no podrían ser utilizados para la fabricación de sub-productos o para abastecer mercados locales.

La prospección de camarones en las costas de la Guayana Venezolana, frente al delta del Río Orinoco, no ha dado resultados positivos hasta el momento presente, para las especies comerciales más importantes. El camarón seis barbas (*Xiphopenaeus kröyeri*) se encuentra en cantidades comerciales hasta una profundidad de 20 brazas, pero no se aprovecha en escala en que podría hacerse. Existe una pesquería de camarones del género *Penaeus* en Guayana y otras importantes en Surinam y Guayana Francesa, estimándose que en el año 1963 existían de 100 a 150 arrasteros de los Estados Unidos pescando camarón en la región de las Guayanas. Puede decirse que la explotación comenzó en 1957. En 1964 la producción regional fué de unas 5 000 toneladas (Idyll, 1966).

En las naciones de Surinam y Guayana el camarón seis barbas se utiliza comercialmente más que en Venezuela, sus posibilidades de explotación están aún lejos de haber alcanzado el límite.

En los fondos de arena y cascajo los rendimientos son mucho menores que en los fondos fangosos. Existe una gran variedad de especies de las familias Pomadasyidae, Lutjanidae, Sphyraenidae, Scorpaenidae, etc. Ocasionalmente se capturan carites (*Scomberomorus maculatus*, y *Scomberomorus cavalla*) en cantidades comerciales al arrastre. La especie más importante en estos fondos, desde el punto de vista comercial, es el panchito (*Pristipomoides aquilonaris*), pero sus rendimientos tampoco son muy prometedores. En conjunto, estos fondos ofrecen pocas perspectivas para la pesca de arrastre en la región de las Guayanas.

Entre 50 y 100 brazas aproximadamente, frente a las costas atlánticas de Venezuela, la especie más importante en los fondos de roca es el pargo o cioba. Existe una pesquería comercial de esta especie con anzuelo, efectuada por pequeñas embarcaciones que van desde Isla Margarita y otros puertos de la región oriental y venden el producto de su pesca en Puerto La Cruz o la Guaira. Junto con esta especie se capturan también el mero *Epinephelus flavolimbatus*. El pargo o cioba también se explota en Guayana Francesa, desembarcandose 200 toneladas en 1966, y en Guayana donde en 1961 existían 8 embarcaciones dedicadas a la pesca de esta especie.

En toda región de las Guayanas la pesquería de pargo o cioba se encuentra en el borde de la plataforma continental, y sobre el talud.

Los *recursos pesqueros estuarinos* de las tres regiones consideradas, son muy poco conocidos y no existen estadísticas apropiadas de capturas. Los mismos se encuentran representados principalmente por los bagres y las lisas entre los peces y camarones como *Xiphopenaeus kröyeri*.

3 NECESIDADES DE INVESTIGACION

Aunque las características hidrográficas generales del área son conocidas, existe muy poca información sobre los fenómenos de pequeña y mediana escala, que puden tener una influencia directa en la presencia o abundancia de los recursos pesqueros de la plataforma continental. Especial importancia tiene el conocimiento de la influencia de la crecida de los grandes ríos en el comportamiento y distribución de la fauna de los fondos fangosos. Sobre este punto es necesario insistir en la necesidad de una investigación continuada.

Los datos de producción primaria son también sumamente escasos. El "standing crop" del área considerada se estima en 150 mg/m^3 (Laevastu,1961; Richardson, 1964) con un máximo de 300 mg/m^3 en la frontera entre Guayana y Venezuela. Estas estimaciones pueden estar lejos de representar la verdadera situación y es necesario realizar más estimaciones en períodos de tiempo cortos. Las estimaciones de producción primaria neta son de 50 gC/m^2/año (Angelescu y Gneri, 1964), que creemos excesivamente baja. Sería preciso también realizar un estudio más completo de este aspecto básico.

Según Laevastu (1961), los rendimientos por kg/ha eran de 0,8 para los peces pelágicos, 0,7 para los peces demersales y 0,1 para los crustaceos y moluscos, estimando este autor que podría esperarse unos rendimientos de 5,0, 5,0 y 1,5 por kg/ha, respectivamente. De hecho, las exploraciones efectuadas hasta el presente indican que estas cifras pueden ser sobrepasadas ampliamente, por lo menos en algunas zonas de la región de las Guayanas, como Surinam, donde se han alcanzado rendimientos hasta de 25,0 kg/ha y en ocasiones más.

En el campo de la exploración pesquera es necesario también intensificar los trabajos, especialmente en las costas de los Estados de Maranhao y Pará. Hasta el momento presente caba destacar las exploraciones pesqueras del OREGON, desde 1956 a 1966, realizadas principalmente en los fondos rastreables de la plataforma continental; las del COQUETTE, comenzadas en 1957 en las costas de Surinam; las del ORSON II, de 1953 a 1956 en Guayana Francesa; y las de la M/N LA SALLE en las costas de las Guayanas desde 1962 a 1968, con resultados realmente positivos en algunos sectores de los fondos fangosos entre 5 y 25 brazas. Recientemente el programa FAO/Unesco para la región antillana está realizando también exploraciones en las costas de las Guayanas. En Guayana se han realizado trabajos de prospección con embarcaciones de arrastre. Queda sin embargo todavía un amplio margén para la exploración, especialmente en los fondos duros y en los que se encuentran fuera de la plataforma continental.

Entre los recursos actualmente en explotación solamente existen estudios de los atunes y de las langostas, estos últimos realizados por la Estaçao de Biologia Marinha de la Universidade Federal do Ceará, que también tiene en curso de desarrollo estudios biológicos-pesqueros sobre el pargo o cioba y los carites. La fundación La Salle, en Venezuela, tiene en desarrollo el estudio del recurso más importante de la región de las Guayanas, la corvina *Cynoscion virescens*. De los demás recursos existe una ignorancia casi absoluta de la potencialidad pesquera, biología e incluso distribución y sistemática.

En algunos recursos de importancia comercial, como los peces Clupeidae y Engraulidae, el confusionismo en taxonomía o la ignorancia es notable, especialmente en los géneros *Sardinella*, *Harengula*, *Anchoa*, *Anchoviella* y *Engraulis*, imponiendose la necesidad de una revisión que abarque todo el norte y nordeste de Sudamérica, para determinar la categoria sistemática en cada área y la clara diferenciación específica. El género Cynoscion, de gran importancia comercial, se encuentra en curso de revisión.

Se desconoce el área de distribución de muchas especies de peces de importancia comercial. La sardina (Sardinella anchovia) parece distribuirse a lo largo de toda la costa norte y nordeste de Sudamérica, lo que complica los estudios biológico-pesqueros, por desconocerse si existen o no poblaciones aisladas geográfica o ecológicamente.

Otras especies, como algunas corvinas, cuyo límite al norte se consideraba la Isla de Trinidad, penetran en el Mar Caribe, por lo menos hasta las costas cercanas a Colombia; y especies de fondo supuestas endémicas del norte de Venezuela y Colombia se han capturado hasta en las costas del Estado de Ceará.

Es necesario delimitar la distribución de las especies comerciales y determinar la posible presencia de poblaciones aisladas del núcleo principal de la especie.

Todos los aspectos de ciclo vital de las especies comerciales más importantes, son casi completamente desconocidos, debiendose prestar especial atención a los Clupeidae del género Sardinella, a las corvinas, al pargo o cioba, a las langostas, y a los camarones. Estos estudios deben hacerse en relación con las peculiares condiciones hidrográficas del área considerada.

4 POSIBILIDADES DE DESARROLLO

Las pesquerías en todo el área del nordeste de Sudamérica se caracterizan por encontrarse en general sub-explotadas, excepto en algunos casos aislados y locales que ya hemos mencionado, como los de las langostas en la región nordeste del Brasil y el atún aleta amarilla en toda el área considerada. Otra característica peculiar de todo el área es el primitivismo notable de los medios de captura y por lo tanto la baja productividad por pescador. Solamente se han introducido métodos modernos de pesca para la explotación de las langostas, del pargo o cioba, de los camarones y de las corvinas.

En 1960 los desembarcos totales en toda el área considerada fueron de 77 600 toneladas: en 1961, de 91 900 toneladas; en 1962, de 154 700 toneladas; en 1963 y 1964, las capturas disminuyen sensiblemente a 112 000 toneladas; en 1965 y 1966 suben de nuevo a 137 000 y 133 000 toneladas, respectivamente, es decir, no alcanzan la cifra de 1962. Estos datos son sumamente alocuentes, como índice del escaso progreso realizado en esta área en los últimos años.

Según Hempel (1967), solamente en las dos regiones correspondientes a las costas del Brasil, podría esperarse una producción de 500 000 toneladas.

Se puede afirmar que las necesidades principales para el desarrollo de las pesquerías en la área considerada son: aumento del consumo interno, desarrollo de las exportaciones, aumento de información científica, modernización de la flota pesquera y medios de captura, aumento de la producción, medidas de protección.

Resumiendo por regiones, se puede esperar incrementar las capturas de los siguientes recursos pesqueros: nordeste de Brasil - atunes, pargos, peces voladores, carites, cazones, sardinas, langostas, pulpos, calamares y algas; norte de Brasil - bagres, lisas, corvinas, roncador, cazones, rayas, pargos, camarones y mejillones; Guayanas - bagres, lisas, corvinas, roncador, cazones, rayas, carites, pargos, meros, pequeños clupeiformes, camarones y calamares.

De todos estos recursos mencionados, el posible incremento de la producción debería ser dirigido a la exportación de los siguientes: atunes, camarones, langostas, mejillones, pulpos y calamares.

5 CONSIDERACIONES FINALES

Toda el área del nordeste de Sudamérica puede considerarse como una unidad ecológica en la que salvo ligeras excepciones de carácter local se encuentran las mismas especies comerciales en similares facies. El cambio más acusado se encuentra en la región del nordeste de Brasil, debido al considerable estrechamiento de la plataforma continental.

Excepto para el atún aleta amarilla y para algunas localidades muy limitadas donde se explota las langostas, se puede considerar que todos los recursos pesqueros del área se encuentran sub-explotados y podría esperarse un aumento sustancial de las capturas en todo el área.

4.44

Excepto por la presencia de langosteros y pargueros en Brasil y flotas camaroneras de arrastre en Surinam, Guayana y Guayana Francesa, los métodos de pesca en todo el área son sumamente primitivos e ineficientes.

Se ingoran aspectos sistemáticos esenciales de especies de gran importancia económica y la biología y ciclo vital de la mayoría de ellas.

Dada la unidad ecológica mencionada, los estudios sobre las especies tendientes a un desarrollo pesquero no deben realizarse aisladamente por un laboratorio determinado o país, sino que para ser eficientes deben conducirse en cooperación entre los diversos paises y laboratorios que existen en toda el área considerada. Con mayor razón se debe aplicar este criterio a los estudios de hidrografía y producción primaria.

La modernización de la flota y la capacitación de los pescadores artesanales son aspectos esenciales para el desarrollo pesquero del área considerada.

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EXPLORATORY FISHING ACTIVITIES
UNDP/FAO CARIBBEAN FISHERIES DEVELOPMENT PROJECT

by

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UNDP/FAO Caribbean Fisheries Development Project
Bridgetown, Barbados, West Indies

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1 INTRODUCTION

This Project which is sponsored by the United Nations Development Programme with the Food and Agriculture Organization (FAO) as the Executing Agency, became operational on 27 August 1965 and is planned to cover a four year period. The original contribution in cash by the UNDP (Special Fund) amounted to U.S.$1 775 600 while participating countries are contributing the equivalent of U.S.$772 800 over the period and approximately the same amount in facilities, services and personnel.

The area the Project covers extends from Jamaica to the Brazilian border with the following countries participating: France, in respect of French Guiana, Martinique, Guadeloupe and their dependencies; Guyana; Surinam; Trinidad and Tobago; Netherlands Antilles; St. Kitts, Nevis Anguilla; Antigua; Dominica; Montserrat; St. Lucia; St. Vincent; Grenada; Barbados; Jamaica; Dominican Republic; and United States in respect of Puerto Rico.

The Project can be described as a commercial feasibility or pre-investment survey of the fisheries resources of the region, and is divided into three parts which overlap in their operational roles. These are:

(i) Exploratory and demonstration fishing
(ii) Marketing study and demonstration
(iii) Fishermen's training and Fisheries Officers' training.

In addition to the work programme carried out in these three fields, Project professional staff are available to advise individual countries on any aspects of fisheries development including investment financing.

Under contract to FAO, the United States Bureau of Commercial Fisheries organizes and supervises the Exploratory Fishing section of the Project and specialized consultants are made available through the Bureau when required.

2 EXPLORATORY FISHING OPERATIONS

The present review deals only with the exploratory fishing activities of the Project.

2.1 Vessels and Staff

Three vessels are assigned to the Project, these include the 82 ft (LOA) ALCYON and CALAMAR registered in Jamaica and Barbados, respectively. These are combination vessels adaptable to longline, trawl, live bait and mechanical reel fishing operations. The ALCYON and CALAMAR were built in Japan and arrived in the West Indies in November 1966. The third vessel, FREGATA (LOA) is smaller, measuring

56 ft. The FREGATA, registered in the Netherlands Antilles, is also a multiple purpose craft with adaptability to live bait, trap, gill net, troll, trawl and longline fishing. The FREGATA was constructed in England and delivered to the Project in June 1967.

The two larger vessels have ranged widely throughout the Project area carrying out "Japanese-style" longline, live bait and troll fishing for pelagic species; as well as trawl, reel and handline, fish traps and net fishing for bottom species (demersal).

To date, the operations of the FREGATA have been limited to the Lesser Antilles including the Leeward and Windward Islands, Barbados, Trinidad and the Netherlands Antilles.

The vessels are captained by FAO personnel recruited internationally. Other than the captains, all crew are West Indians, when possible, recruited from the country of vessel registry. The regular crew is augmented by fishermen trainees who spend periods up to six months aboard and in general perform as fishermen. In addition to the normal ships' complement, each cruise is accompanied by one or more technical personnel either from the Project staff, counterpart staff (from participating countries), or from other agencies, i.e. University of West Indies; Bellairs Marine Laboratory; Bureau of Commercial Fisheries; etc.

Individual cruise duration is typically 2 - 3 weeks although in certain instances cruises may be longer or shorter.

2.2 Orientation

As the period during which the Project will remain active is limited, particular effort has been made to concentrate operations on endeavours which appear to offer the possibility of productive fishery development. For discussion purposes, this orientation may be broadly categorized as either pelagic or demersal investigations; each of these major categories has received approximately equal attention during the first two years (sixty vessel months) of field operations. Through October 1968, just over 1 000 operational days have been completed by Project vessels.

The exploratory fishing accomplished thus far may be classified as follows:

2.3 Vessel Operations

Method	Percent of Total
PELAGIC	
Longline	12
Live Bait	33
DEMERSAL	
Snapper	16
Trawl	27
Other	12

These categories are briefly discussed below.

Longline. During the latter part of 1966, and in much of 1967, considerable emphasis was put on the longline method of fishing for deep-swimming tunas by the Project vessels ALCYON and CALAMAR. The objective of these operations was to determine whether this method offered substantial potential for development in the Project area. Commercial longline fishing has been conducted within the Caribbean and in adjacent Atlantic waters since the late 1950's. The Japanese in particular have successfully employed this method as have the fishermen from Cuba, Venezuela, and recently Taiwan and Korea. Recent analysis of the existing commercial fishery (Wise, 1968; Griffiths and Simpson, 1968) suggest an overall decline in the availability of tuna to this type of gear.

The fishing results of the ALCYON and CALAMAR using the longline method did not offer encouragement for substantial landings of tuna or related species. Eighty-one tuna longline sets resulted in catches which ranged from 0 to 3 fish captures per hundred hooks set. In addition to the relatively low rate of capture inexperience of the crew, coupled with the turnover of available trainees, did not permit operations much in excess of 100 units (baskets) of gear set per day (Figures 1 and 2). This figure constrasts with 250 - 400 units set each 24 hours by commercial fishermen. A third factor to be

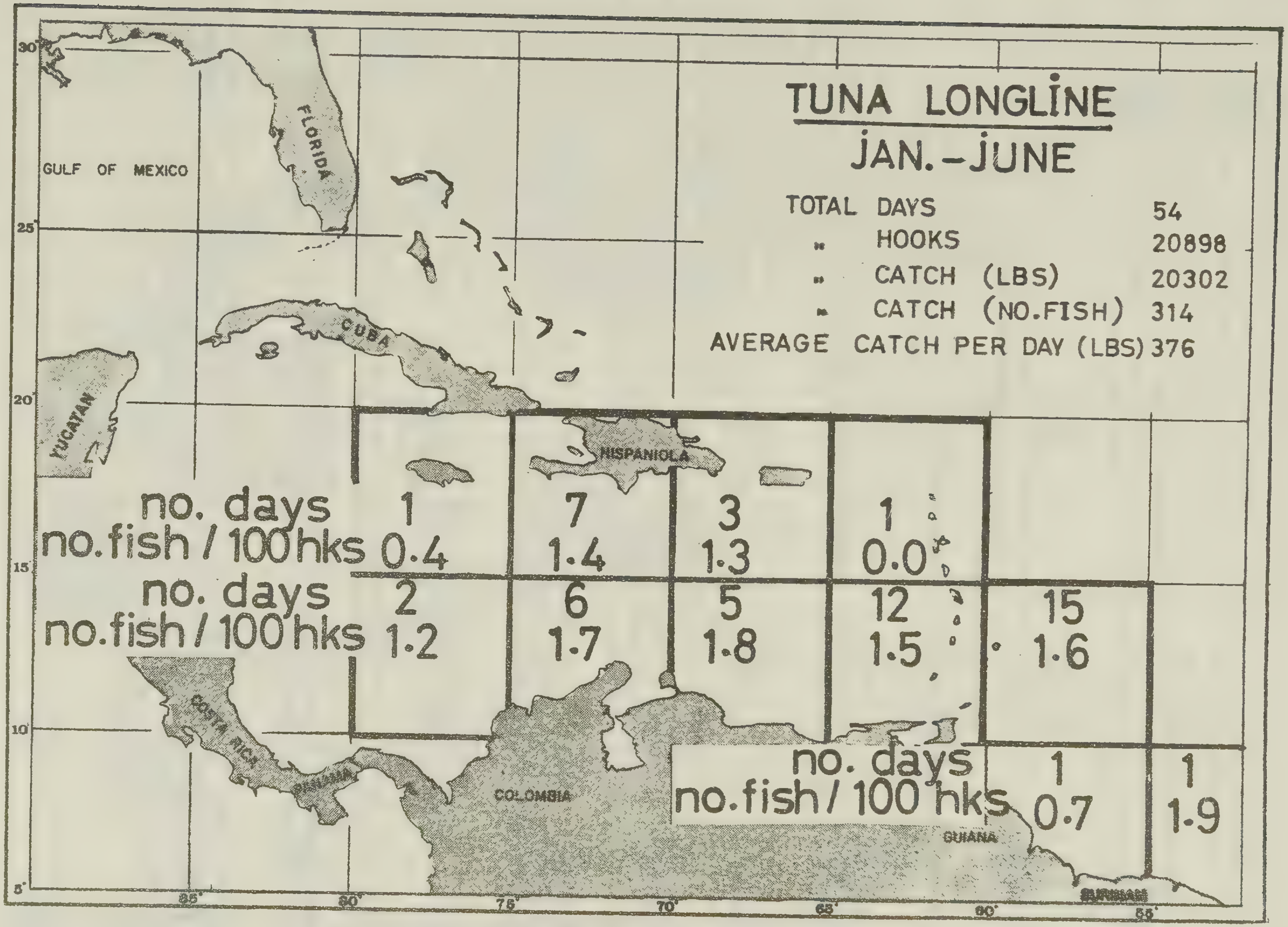
TUNA LONGLINE
JAN.-JUNE
TOTAL DAYS 54
" HOOKS 20898
" CATCH (LBS) 20302
" CATCH (NO.FISH) 314
AVERAGE CATCH PER DAY (LBS) 376
GULF OF MEXICO
FLORIDA
CUBA
YUCATAN
HISPANIOLA
COSTA RICA
PANAMA
COLOMBIA
GUIANA
SURINAM
no. days
no.fish / 100hks
1
0.4
7
1.4
3
1.3
1
0.0
no. days
no.fish / 100 hks
2
1.2
6
1.7
5
1.8
12
1.5
15
1.6
no. days
no.fish / 100 hks
1
0.7
1
1.9
30°
25°
20°
15°
10°
5°
85°
80°
75°
70°
65°
60°
55°

Fig. 1 Results for Tuna longline fishing obtained by the UNDP/FAO Caribbean Fisheries Development Project

4.39

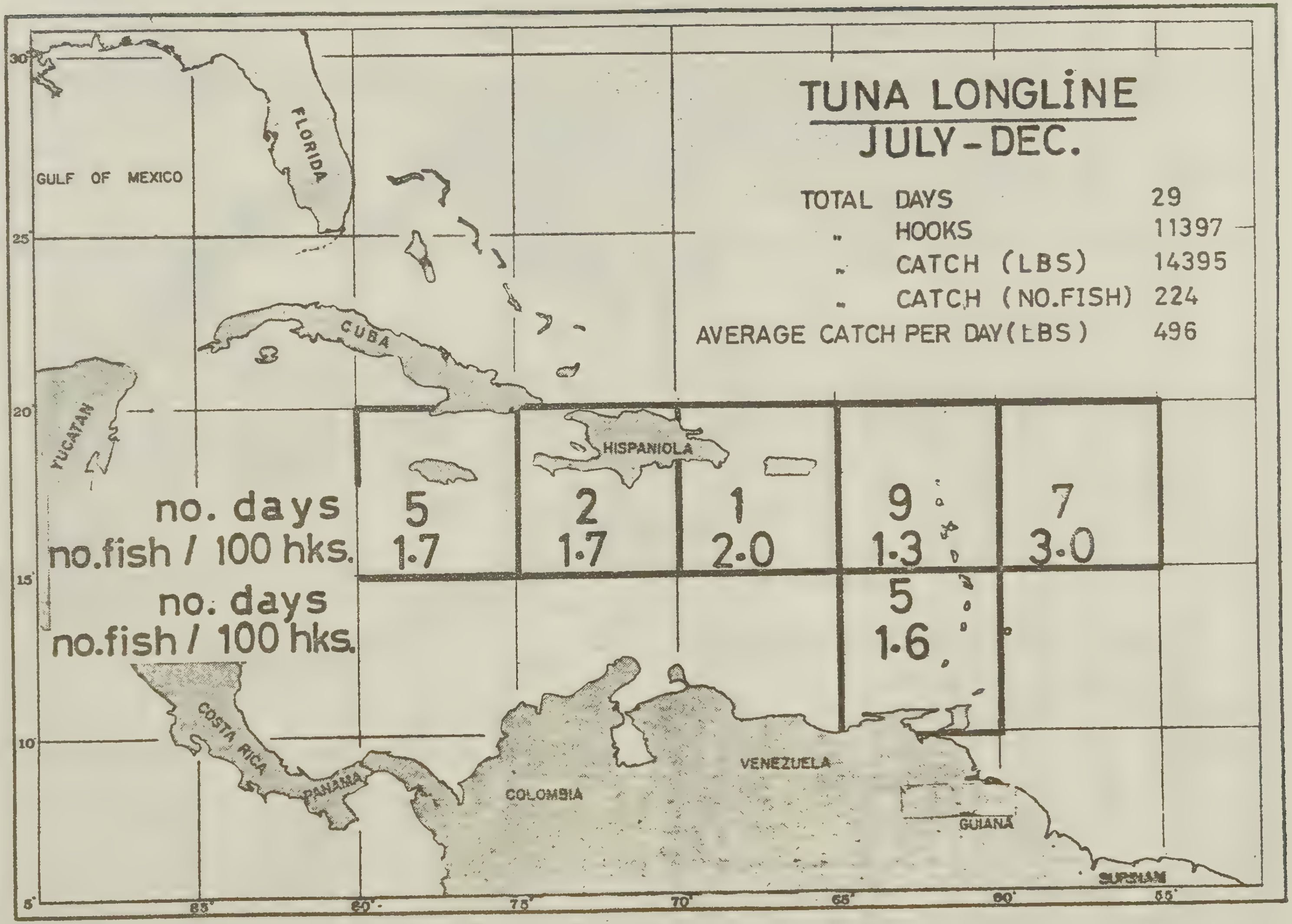
TUNA LONGLINE
JULY-DEC.
TOTAL DAYS 29
" HOOKS 11397
" CATCH (LBS) 14395
" CATCH (NO.FISH) 224
AVERAGE CATCH PER DAY (LBS) 496
no. days
no.fish / 100 hks.
no. days
no.fish / 100 hks.
5
1.7
2
1.7
1
2.0
9
1.3
7
3.0
5
1.6
GULF OF MEXICO
FLORIDA
CUBA
YUCATAN
HISPANIOLA
COSTA RICA
PANAMA
COLOMBIA
VENEZUELA
GUIANA
SURINAM
30°
25°
20°
15°
10°
5°
85°
80°
75°
70°
65°
60°
55°

Fig. 2 Results for Tuna longline fishing obtained by the UNDP/FAO Caribbean Fisheries Development Project

considered is the desirability of tuna longline vessels ranging over a wide area of the ocean, i.e. Caribbean, Central Atlantic, equatorial region in the course of a single year's operation. Since the Project was charged to develop "regional (West Indian)" resources, this last mentioned factor contribute to ceasing indefinitely further investigations using the longline method by the Project.

Live Bait Fishing. In part, due to the limited success experienced in using the longline technique, and considering the fact that much of the environment of West Indian waters appears suited for pelagic species, the technique of live bait fishing was attempted. Considering all exploratory operations of the Project, this category has received the greatest (33%) amount of effort.

Basic objectives were set out as follows:

(i) Define geographic and seasonal distribution of tunas and/or related surface school fish.

(ii) Develop information on the availability of suitable live bait.

(iii) When and where practical, to conduct experimental fishing on concentrations of fish using the live bait technique.

Over 2 000 hours of scouting for fish schools throughout the Caribbean has provided information on the relative abundance of fish schools in different seasons. When evaluated by 5° squares, the frequency of sightings ranges from no schools observed to one school every three hours. These data are summarized in Figures 3 and 4.

An inherent factor in successful live bait fishing is the availability of live bait. Moderate to good success has been experienced in obtaining live bait using an underwater light to attract bait which is then captured by the use of a lift net. Varieties of bait found in abundance have included the following genera Sardinella, Harengula, Opisthonema, Jenkinsia and others.

On several occasions fishing attempts have resulted in catches of up to 1 400 lb of skipjack taken from a single school. Catches of this magnitude have not been consistent however. It may be that alternate methods, i.e. seine, gill net or other might be more successful in harvesting these species.

Trawl Fishing. The CALAMAR has been detailed to exploratory and production trawling for 18 months which accounts for about 27 percent of the aggregate vessel effort to date. Over 1 000 hours trawling have been completed from the area off Margarita Island (Venezuela) east to the Brazilian border.

Production demonstration fishing in the Surinam area has consistently produced good catch rates for sea trout, croaker, and other species. Overall trawl results have been summarized in Figure 5, while Figure 6 illustrates seasonal catch rates and composition.

Analysis of availability, consumer acceptance and production costs demonstrate that sufficient knowledge is available to encourage development of this resource.

Snapper Fishing. Although relatively less effort has been devoted to "snapper" fishing as compared to other major categories of live bait fishing and trawling, results to date have been encouraging.

Exploratory coverage ranged from the shelf off Central America (Nicaragua) east to the Leeward Islands (Antigua). Excellent results were experienced at a number of locations throughout this range. During May and June 1968, an experimental "mothership" operation was conducted by the ALCYON. This vessel carried on independent fishing activities as well as functioning as a base of operations for 2 to 3 small, outboard-powered boats. During these cruises, eighteen days fishing yielded over 40 000 lb of good quality marketable fish. Average daily catches were over 2 200 lb.

4.39

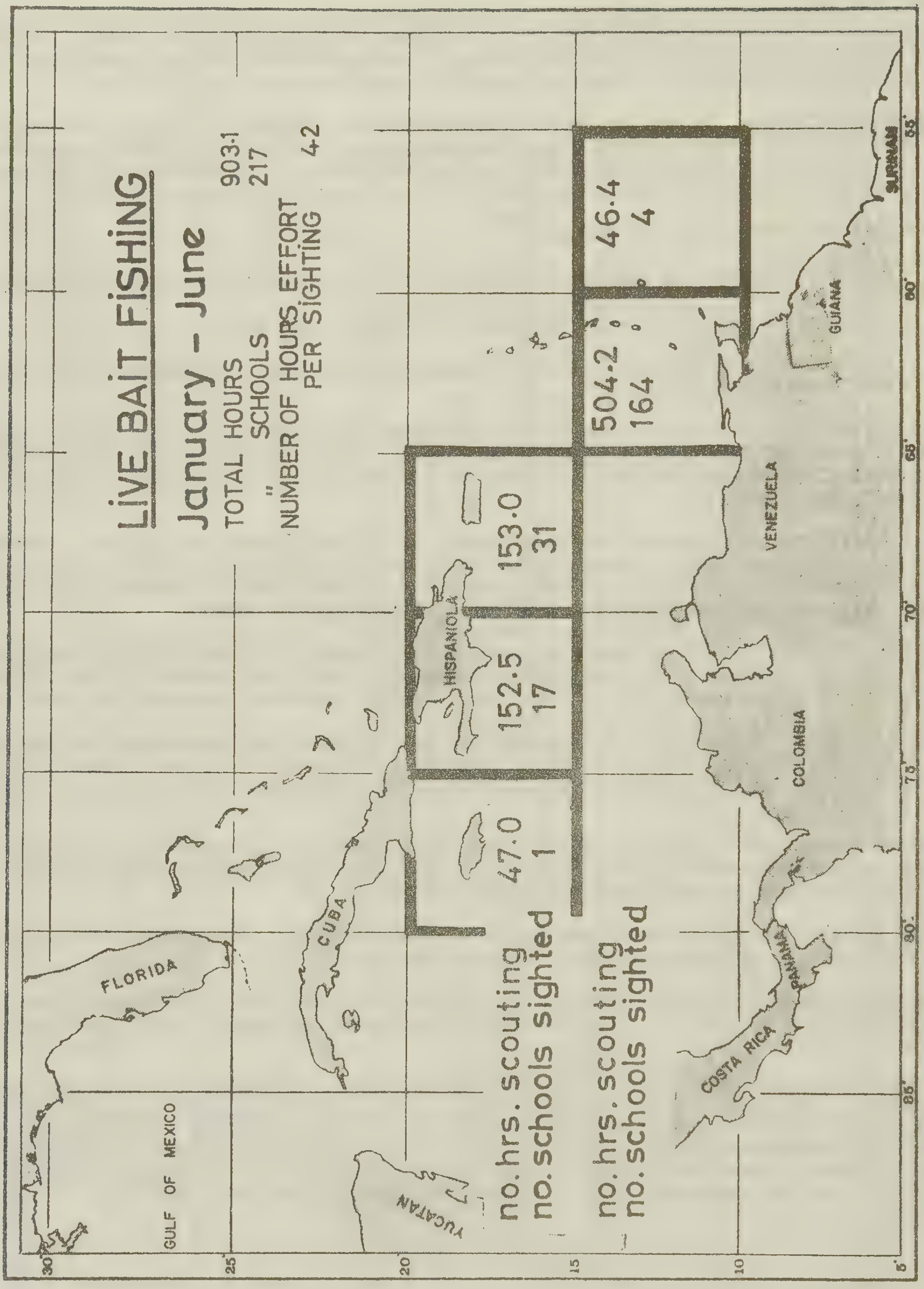
LIVE BAIT FISHING
January - June
TOTAL HOURS 903.1
" SCHOOLS 217
NUMBER OF HOURS EFFORT PER SIGHTING 4.2
46.4
4
504.2
164
153.0
31
152.5
17
47.0
1
no. hrs. scouting
no. schools sighted
no. hrs. scouting
no. schools sighted
GULF OF MEXICO
FLORIDA
CUBA
HISPANIOLA
YUCATAN
COSTA RICA
PANAMA
COLOMBIA
VENEZUELA
GUIANA
SURINAM
30°
25°
20°
15°
10°
5°
85°
80°
75°
70°
65°
60°
55°

Fig. 3 Results for live bait fishing obtained by the UNDP/FAO Caribbean Fisheries Development Project

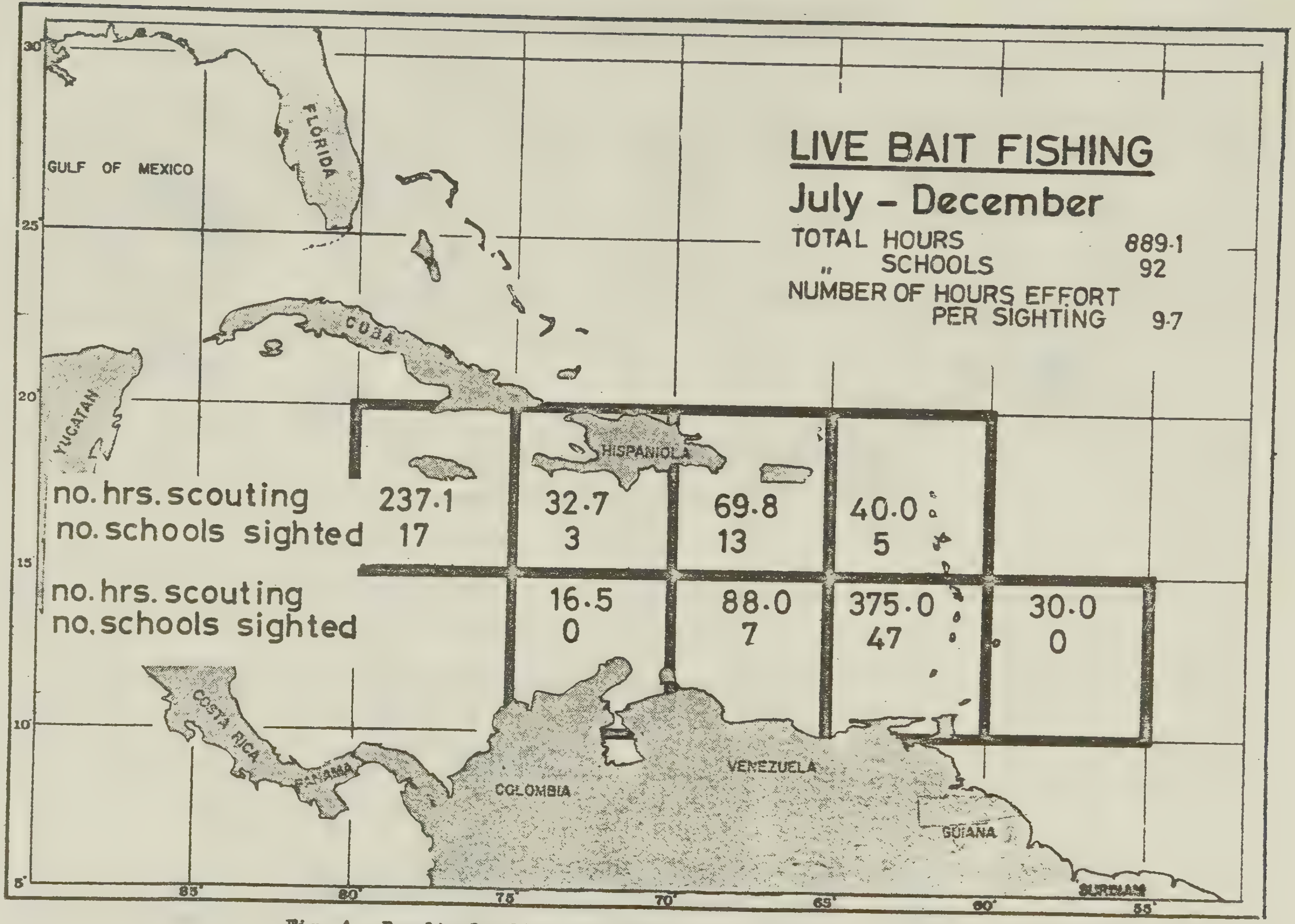
LIVE BAIT FISHING
July - December
TOTAL HOURS 889·1
" SCHOOLS 92
NUMBER OF HOURS EFFORT PER SIGHTING 9·7
no. hrs. scouting
no. schools sighted
237·1
17
32·7
3
69·8
13
40·0
5
no. hrs. scouting
no. schools sighted
16·5
0
88·0
7
375·0
47
30·0
0
GULF OF MEXICO
FLORIDA
CUBA
YUCATAN
HISPANIOLA
COSTA RICA
PANAMA
COLOMBIA
VENEZUELA
GUIANA
SURINAM
30°
25°
20°
15°
10°
5°
85°
80°
75°
70°
65°
60°
55°

Fig. 4 Results for live bait fishing obtained by the UNDP/FAO Caribbean Fisheries Development Project

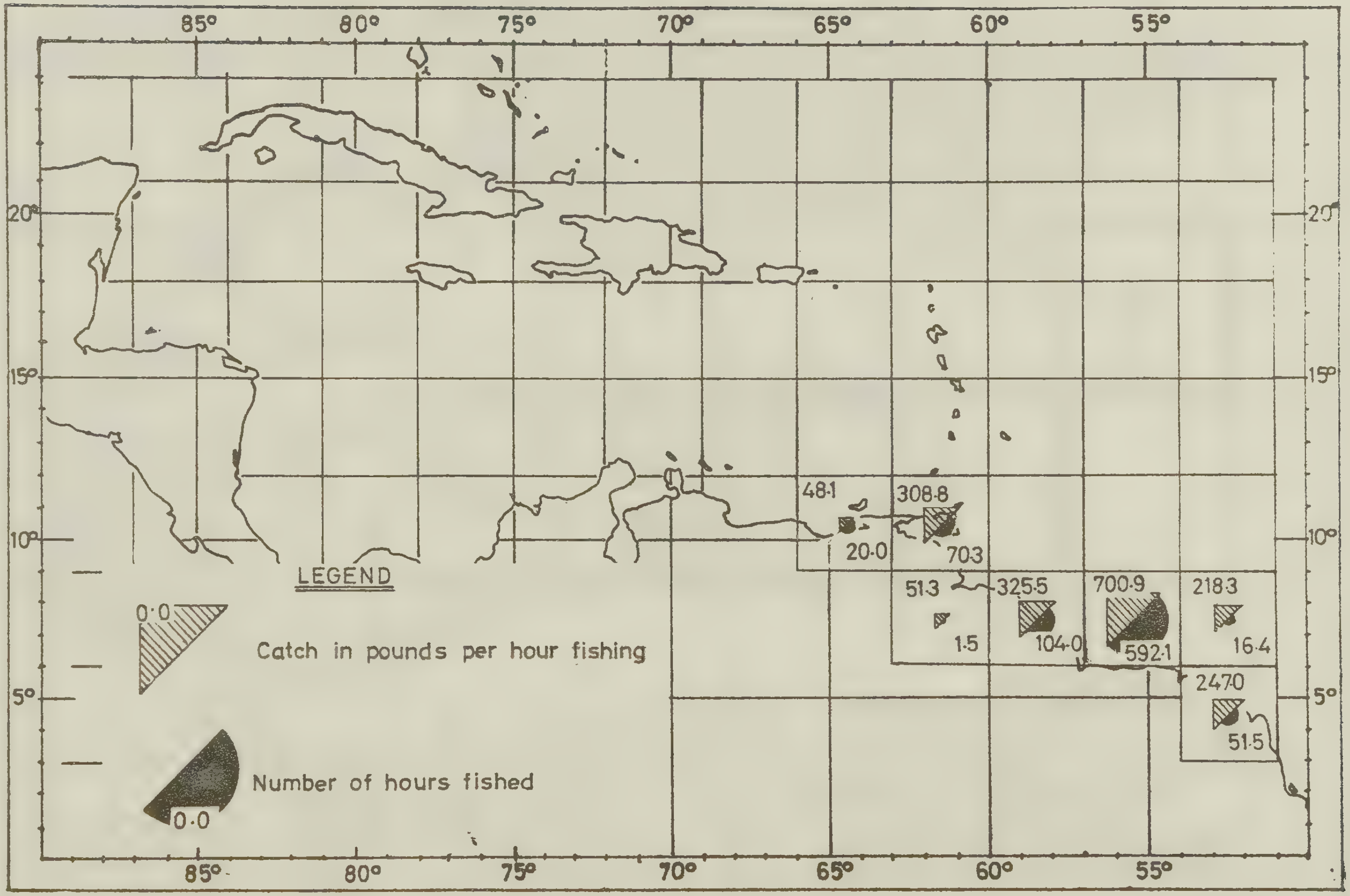
85°
80°
75°
70°
65°
60°
55°
20°
15°
10°
5°
48·1
20·0
308·8
70·3
51·3
1·5
325·5
104·0
700·9
592·1
218·3
16·4
247·0
51·5
LEGEND
0·0
Catch in pounds per hour fishing
Number of hours fished
0·0

Fig. 5 Trawl Fishing by M/V CALAMAR (total effort) of the UNDP/FAO Caribbean Fisheries Development Project

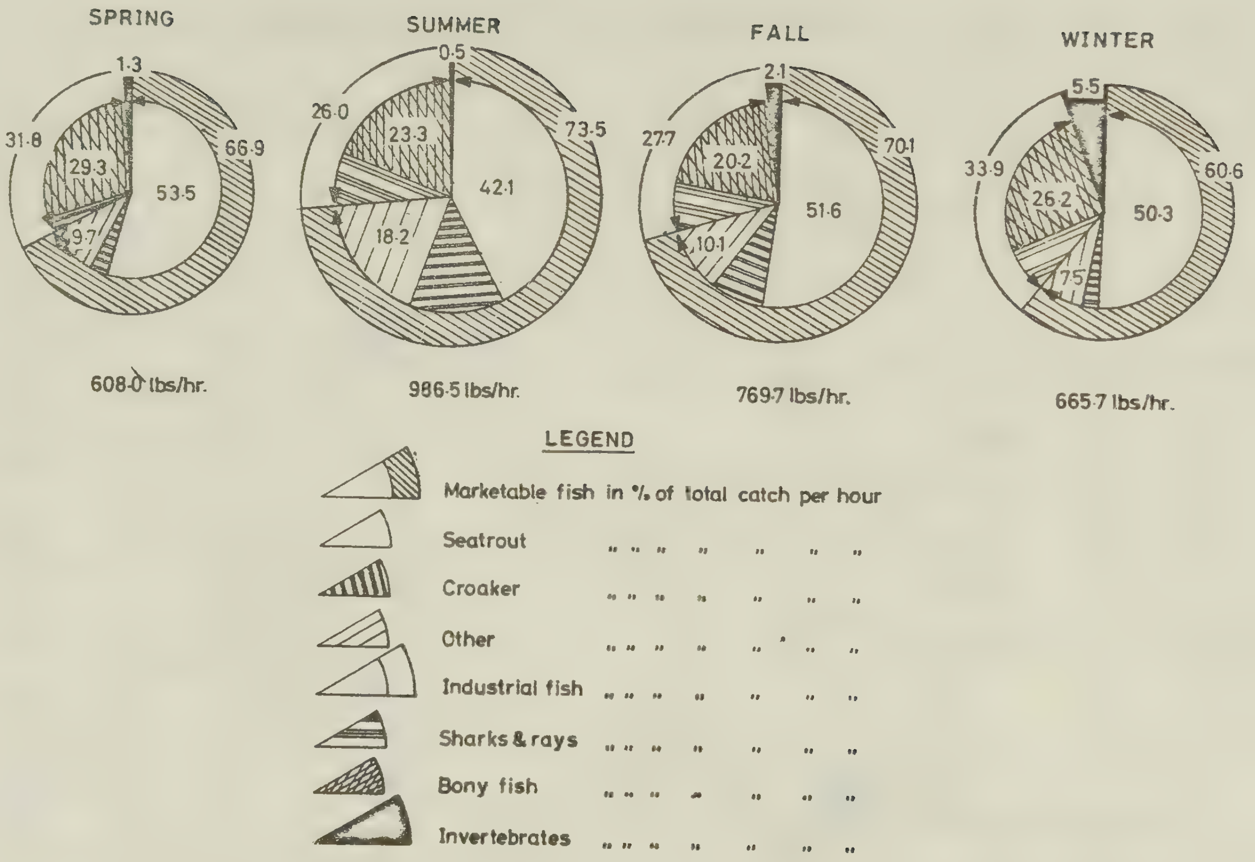

Fig. 6 Trawl catch composition and seasonal catch rate in grid S-36°
(UNDP/FAO Caribbean Fisheries Development Project)

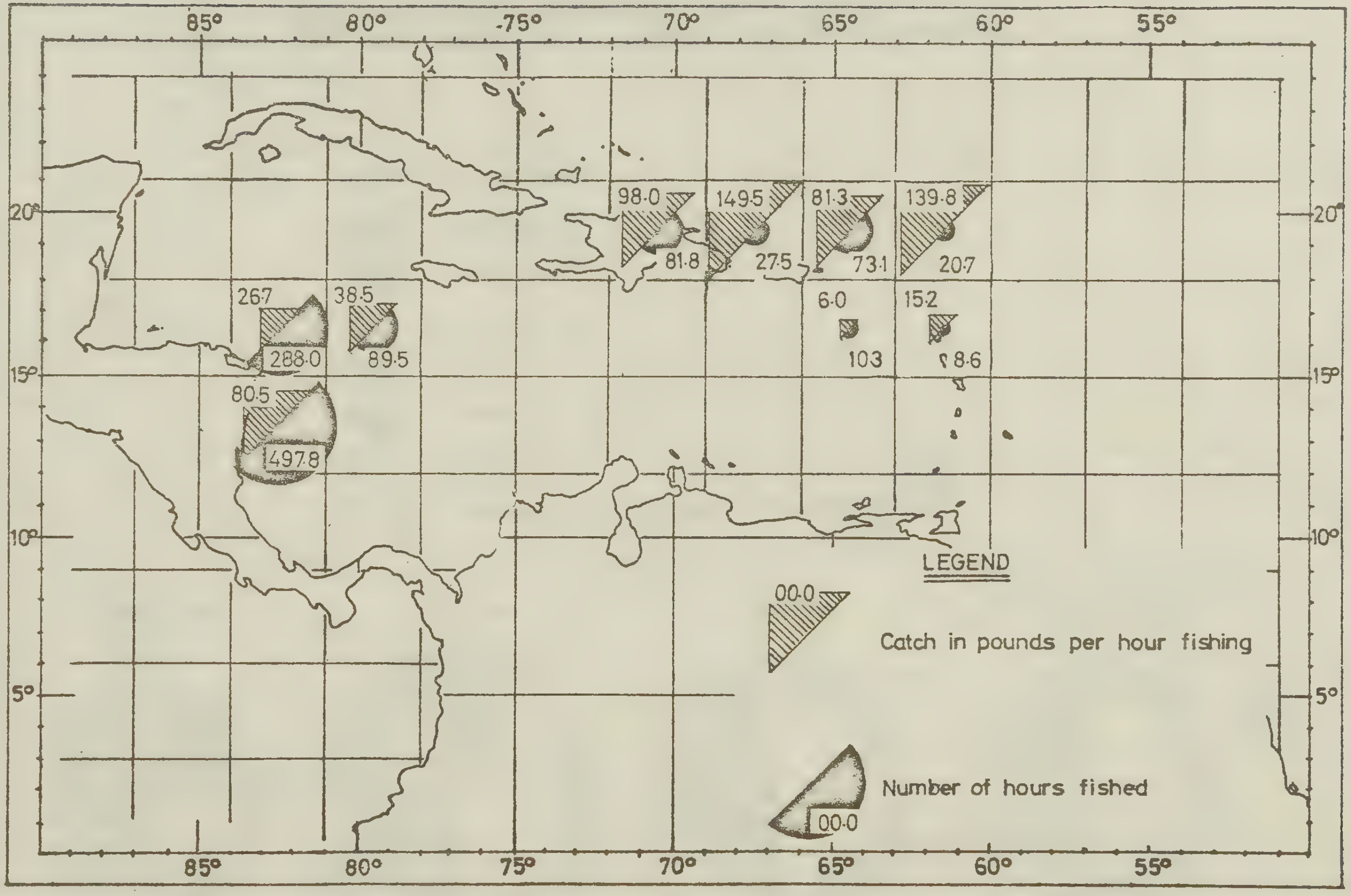
85°
80°
75°
70°
65°
60°
55°
20°
15°
10°
5°
98.0
81.8
149.5
27.5
81.3
73.1
139.8
20.7
6.0
10.3
15.2
8.6
26.7
288.0
38.5
89.5
80.5
497.8
LEGEND
00.0
Catch in pounds per hour fishing
00.0
Number of hours fished

Fig. 7 Handline fishing by M/V ALCYON (during cool season) (January–June 1968)
(UNDP/FAO Caribbean Fisheries Development Project)

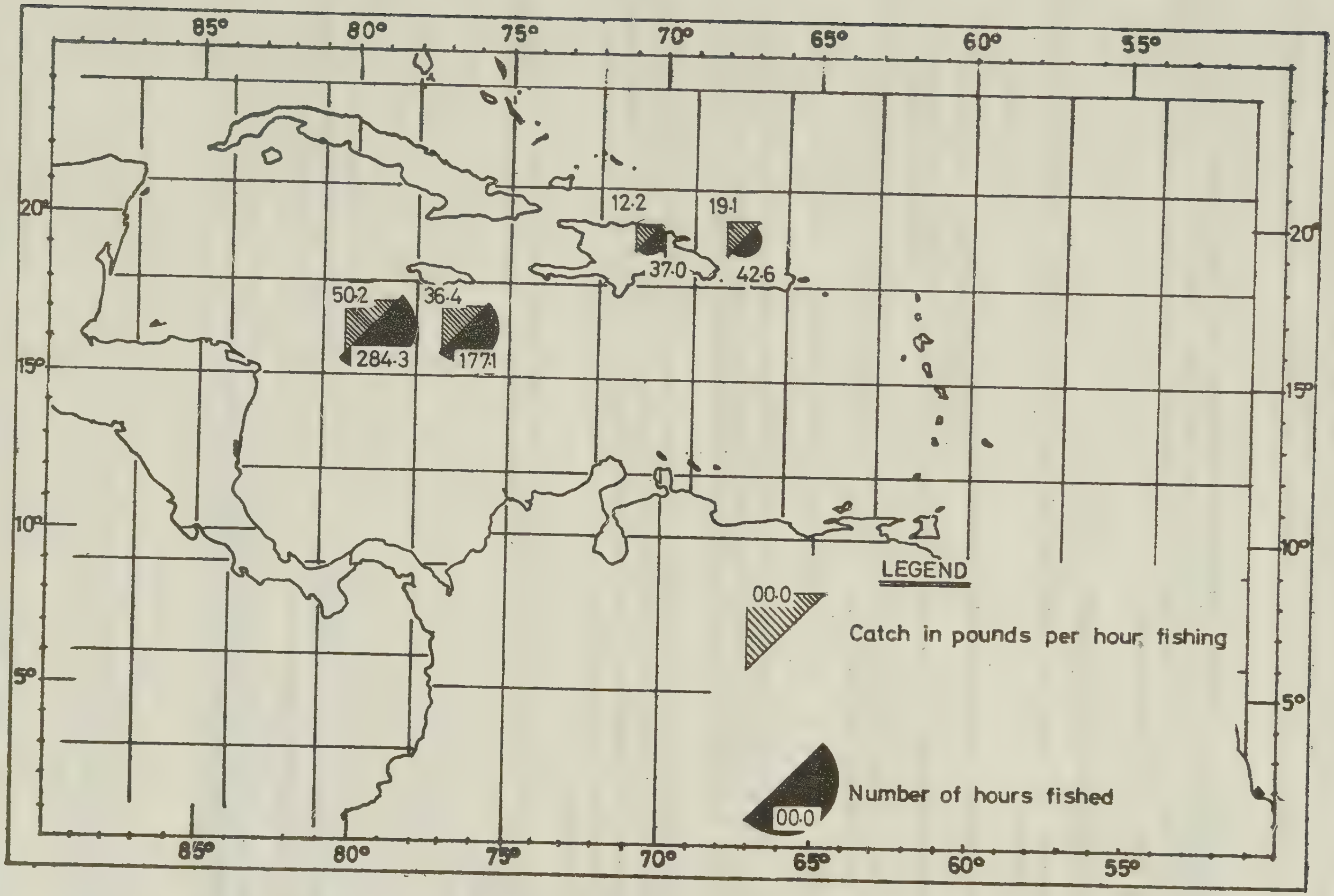
85°
80°
75°
70°
65°
60°
55°
20°
15°
10°
5°
12·2
37·0
19·1
42·6
50·2
284·3
36·4
177·1
LEGEND
00·0
Catch in pounds per hour fishing
00·0
Number of hours fished

Fig. 8 Handline fishing by M/V ALCYON (during warm season)(July-December 1968)
(UNDP/FAO Caribbean Fisheries Development Project)

Recent developments include equipping the FREGATA with electric-powered reels. October reports have indicated individual catches of over 1 000 lb a day from the Leeward Islands.

Overall range and results of handline and mechanical reel fishing operations are illustrated in Figures 7 and 8.

Other Fishing Methods. Various experimental techniques have been attempted from time to time. These have included the following fishing methods: troll, gill net, fish trap, lobster trap, bottom set line, dredge fishing, etc. For the most part none of these methods have been used enough to offer analysis of their (its) usefulness.

2.4 Future Exploratory Fishing Programme

A tentative schedule for operations into 1969 now includes three major categories of effort, these are in order of dominance:

1. Snapper fishing, with emphasis on broader geographic coverage.
2. Experimental fishing for sharks, to be coordinated with processing and marketing.
3. Live bait fishing with intensified coverage at locations where sightings have been high, e.g. the southeastern Caribbean.

3 OTHER PROGRAMMES

Bathythermograph and salinity observations are recorded in conjunction with pelagic fishing operations. Original data are deposited with the Tropical Atlantic Biological Laboratory (B.C.F.) at Miami. In cooperation with this institution, drift bottles have been released throughout the Project area.

Fish tagging has been conducted in cooperation with the Woods Hole Oceanographic Institution (pelagic species) and the U.S. Fish and Wildlife Service (Sharks). Biological specimens (particularly fish) have been preserved and forwarded to various institutions in the West Indies, North America and Europe. Effort has been made to provide space in the vessels or to record observations during cruises for cooperating scientists.

Summary reports of cruise activities are released routinely as "Cruise Reports". Details of fishing operations are tabulated and disseminated as "Fishing Logs". Overall summary reports are prepared as warranted.

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DISTRIBUTIONAL PATTERNS OF FISHES FROM COASTAL AND SHELF WATERS OF THE TROPICAL WESTERN ATLANTIC[1]

by

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1 INTRODUCTION

In introducing this paper I wish first to define the area to be treated, first topically, then geographically. In dealing with fishes from coastal and shelf waters we are discussing species that live from the waters[1] edge to about 200 meters and with particular attention to bottom-dwelling species. In so doing I recognize that some oceanic fishes regularly cruise into shelf waters and that some may come almost to the waters' edge near oceanic islands. I also recognize that the larval and early juveniles of some oceanic species (for example the dolphins, Corypheana, and many flyingfishes, Exocoetidae) regularly inhabit shore waters and contribute to the food chains in those waters. Conversely the larvae of many coastal fishes inhabit oceanic waters and those of one group, the eels, may play a vital role in energy transfers in the epi- and meso-pelagic zones.

Knowledge of such life history patterns is important to the understanding of distributional patterns, and thus to some extent the discussion of only one unit of the fish fauna of the tropical western Atlantic namely that of the shelf and shore waters, is arbitrary.

Geographically this convention is, by definition, primarily concerned with the Caribbean Sea. To understand the distribution of fishes in this region, we must go well beyond the boundaries of the Caribbean Sea to include the Gulf of Mexico, the Bahama Islands, and the southeastern United States to the north, and the coast of South America, at least as far as the hump of Brazil, to the south.

Despite the early settlement of lands surrounding the Caribbean, despite the long interest in food resources from the sea by peoples in lands surrounding this region and despite the tremendous growth of tourism in the tropical islands with associated development of sport fisheries, knowledge of the fish fauna remained in a primitive state until the 1950's.

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[1] Contribution No. 000 from the Institute of Marine Sciences, University of Miami

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This is not to say that collections had not been made in the region for, as Dr. Bayer has shown, descriptions of some tropical Atlantic fishes date back to the 1500's and reports during the 19th and first half of the 20th century are numerous. Most of these reports concerned miscellaneous collections, usually not made by the authors themselves, and made in haphazard fashion without regard to larger problems such as a thorough survey of an island's fauna and with little, if any, attention to ecology or even precise geographic information. If all past collection sites were plotted on a map an outsider could well wonder if we ever needed to collect another fish from the tropical Atlantic. Unfortunately most old collections are of historic interest only. Moreover, because of the selection of sites for collection and the equipment used an incredible number sampled the same fishes repeatedly without coming close to surveying a cross section of the fish fauna.

As we move into a period of synoptic studies of genera and families of fishes it is a common experience for the ichthyologist to find that six or seven names available in a genus all apply to one wide ranging species that happens to be common near sea ports and that all other species that he now has before his are undescribed.

By 1950, provisional lists, which were based on sufficient work to have a right to purport to be complete, existed only for Puerto Rico (Everman and Marsh, 1900), the Tortugas - west of Key West, Florida (the various works by W.H. Longley, particularly that by Longley and Hildebrand, 1940), Cuba (the various works by Felipe Poey in the mid and late 1800's and studies by Luis Howell Rivero in the 1930's) and western Haiti (Beebe and Tee-Van, 1928).

Even these works suffered because of limitations of collecting gear, usually trawls, beach seines and hook and line which can only sample certain habitats and which are selective as to size and kinds of fishes caught. Of the works mentioned only those involving William Beebe and William Longley employed extensive underwater observation. Longley pioneered in underwater observation and he was a keen and knowledgeable observer but, alas, his notes were poorly kept and most of his knowledge of the Tortugas fishes died with him.

Other regional publications prior to 1950 varied from competent study of individual collections of fishes to reports that were so carelessly done as to interfere with progress of knowledge.

The increase in knowledge of tropical Atlantic waters started a dramatic upswing in the post second world war years and may be attributed principally to three factors. First there was a blossoming of ichthyology itself, particulary in the United States but also elsewhere in the Americas; where one ichthyologist laboured 25 years ago there are now four or five. By example in 1950 there was only one full time ichthyologist in the state of Florida. There are now at least 21 and this excludes many highly competent graduate students, and a host of fishery biologists and marine biologists who devote varying amounts of time to the study of fishes. The same is true, though to a lesser extent, for the countries of the Caribbean. Universities in the United States and throughout the Caribbean have increased, and properly so, their attention to the sea. I cannot help but compare the Institute of Marine Sciences of the University of Miami in 1968 to that of 1950 and I ask each of you to think back on your own institution and its outlook as it existed in 1950.

A second reason for the sudden increase in knowledge is the development and popularization of underwater observation through use of face mask, snorkel and flippers and scuba and other diving gear. And a third reason was the use in the sea of ichthyocides of a wide variety. These substances began to reveal the true extent of the burrowing and rock-and reef-dwelling fish faunas and the experience was common to collect at a single station dozens or hundreds of specimens of a species previously known only from one damaged specimen collected by a lucky stroke of a grab or dredge.

The tropical Atlantic fish fauna is rich and diverse, much more so than was believed. Böhlke and Chaplin (1968) record 507 species mostly from the upper 100 feet of Bahamian shelf waters and Starck (1968), summarizing ten years of work at Alligator Reef, reports 517 fish species from this small area in the Florida Keys, one of the most dense associations of fish species known. Forty-four of the species on Starck's list have been described since 1956 and nearly 100 represent species unknown from waters of the United States in 1956.

Rass and Juarez (1967), not restricting their attention to shallow-water fishes, state that there are more than 866 species in Cuban waters. This would compare to about 1 350 species for Florida. No one has attempted a list of species for the tropical Atlantic. My own estimate is that there are between 2 000 and 2 500 species of which more than 50 percent are inhabitants of shelf and coastal waters.

These detailed studies and other similar contributions make it possible to analyse patterns of distributions of fishes in the tropical western Atlantic. This analysis is based largely on the faunas of the following regions which are best surveyed. In some instances reports on these surveys are still unpublished: the Bahama Islands (the works of James E. Böhlke of the Academy of Natural Sciences of Philadelphia, and numerous colleagues, as summarized by Böhlke and Chaplin, 1968), southeastern Florida (the works of the staff and graduate students of the Institute of Marine Sciences of the University of Miami), Puerto Rico and the Virgin Islands (studies by John E. Randall, at the time on the staff of the University of Puerto Rico and the University of Miami), Jamaica (Caldwell, 1966, plus collections by Randall), Cayman Islands (collections and reports by Carter R. Gilbert), Cuba (Duarte-Bello, 1959), Dominica and Antigua (surveys by the Smithsonian Institution's staff, particularly Dr. Victor G. Springer), Venezuela (Cervigón, 1966 and surveys of Los Roques by Donald P. de Sylva, Francisco Mago and others) and the extensive shelf and shore surveys from Yucatan to Trinidad by R/V PILLSBURY (under the leadership of Dr. Gilbert L. Voss of the University of Miami), of the U.S. Fish and Wildlife Service vessels, OREGON, SILVER BAY and COMBAT (under the direction of Harvey R. Bullis, Jr.), and of the COQUETTE in Surinam's waters. Many ichthyologists in addition to those mentioned have aided in these studies and have provided specimens and information to me and to my students. Without such help a summary of this sort would not be possible.

This paper will describe and characterize the major patterns of distribution that are emerging. It should not be expected that all species can be so categorized but, surprisingly, the patterns apply not only to reef and benthic coastal fishes but to pelagic species that swim in shallow waters and to at least some species of the continental slope. We may term these patterns Continental and Insular and we will consider two additional types. These units are easily described geographically but it is clear that no important physical barrier exists to prevent mixing of these faunas. The meaningful definitions of these units involve ecological parameters which are themselves geographically distributed.

2 THE TROPICAL CONTINENTAL FISH FAUNA

Continental species require environments where change is a way of life, change due to seasonal shifts in continental climates unbuffered by broad stretches of ocean, change due to run off from large rivers, and change due to turbidities caused by winds that stir rich bottom sediments. Broad muddy embayments are common and estuarine influence strong. Species characteristic of continental waters may be divided into northern and southern types though some occur through both sections.

Geographically, and with regard to tropical and subtropical fishes or at least fishes of tropical origin, the northern continental fauna extends from Cape Canaveral on Florida's east coast south to the tip of Florida, around the Gulf of Mexico to Yucatan and through Cuba in diminishing representation to Hispaniola and Jamaica. A considerable number of species are absent from the northern shores of the Gulf of Mexico during all but the warmest months of the year and those preferring rock of shore lines almost never occur there. Also during the summer months species of this group may extend their distributions north along the east coast to the Carolinas.

Southern species occur along Brazil's north coast, the Guianas and Venezuela and in pockets in the mud shadows of the river mouths from Colombia to Nicaragua. These pockets show a mixture of southern and northern types the shift being largely complete south of Mexico. Southern types also reach Jamaica in small numbers and mix there with northern continental types.

The reason for the inclusion in the range of these species of Cuba and Hispaniola and, to a lesser extent Jamaica, lies in the high mountains that these islands possess with consequent high rain falls, permanent river systems and broad muddy embayments. Thus we can expect these species to predominate where shelf waters are broadest and most influenced by run-off. Such areas include the Gulf of Batabano in southern Cuba and the Gulf of Gonaives in western Haiti.

It is not my intention to describe to you the distribution of even each major group of fishes nor do I wish to concern us with minor differences in limits of distributions. I do wish to discuss representatives that I think best typify the problem and which I think will bear on the development of fisheries in the Caribbean.

The continental pattern is typified by the Sciaenidae, a family containing important food fishes such as the seatrouts, croakers and drums. Of twenty-two species that occur in Florida's shore waters only four occur in the Bahamas. Three of these, species of Equetus, are reef dwellers that are properly called insular species and that, in fact, in Florida occur only along the border of the Florida Current. The fourth, Umbrina coroides, inhabits open sandy beaches where there is surf, a special environment to which relatively few fishes adapt. Burrowing species such as snake eels are especially dependent on bottom sediment. None of nine continental species of the genera Ophichthus, Bascanichthys, Mystriophis and Letharchus occurs in the Bahamas. The free swimming, migratory Spanish mackerel, an important food fish, is broadly distributed in continental waters from Brazil to the United States. It occurs in Cuba and Hispaniola as well but is absent from the Bahamas and as Erdman and Roman (1959) noted, it is also absent from Puerto Rico, supposed records there being based on the rather similar juvenile king mackerel.

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The same situation exists in the south for South America's very rich sciaenid fauna which is almost entirely excluded from the islands and so, too, the Spanish mackerel.

It is important to realize that geographic barriers are not operating to restrict the continental element from the islands but instead that ecological conditions and competition from closely related and better adapted island species provide the barrier to colonization. What we have in these faunas is not a picture of what could reach the area in question but of what could survive and breed once there. Again we turn to south Florida for an example. The Warsaw grouper, Epinephelus nigritus, a large species (commonly reaching several hundred pounds) inhabits deep shelf waters around rocky ledges and sea mounts particularly in the 80 to 300 m range. Although a broad latitudinal range it has never reached the Bahamas where it is replaced ecologically by the misty grouper Epinephelus mystacinus.

Ten years of collection along the south Florida shore line has resulted in two records of insular misty grouper (Robins, 1967). Strays of this sort are to be expected but they serve to emphasize rather than destroy the distinctness of the continental insular faunas. Of the continental species that reach the Bahamas, most are known from a few records from along the western side of the Bahamas. As studies progress more strays will be found and the list of Bahamian fishes will grow as a result. A list of the known fishes has little meaning to one searching for an unused resource. One can predict that, strays notwithstanding, continental species like the Spanish mackerel (Scomberomorus maculatus) and the Warsaw grouper (Epinephelus nigritus) will not become established in the insular province.

What the strays will demonstrate in convincing fashion is that ecology of the area and not physiographic barriers have resulted in the separation of the continental fauna from the insular fauna.

3 INSULAR FISH FAUNA

The distinctive and species-rich island fish fauna requires clear waters, buffered environmental conditions, and bottom sediments largely of calcium carbonate. In areas of steep drop-offs clear ocean waters pound sediment free rocky cliffs or wash variously developed fringing reefs. This fauna occurs from the Bahama Islands south to the islands off South America such as Curaçao, Cubaqua, and Los Roques. This faunal element is acentrically distributed for it is in the north in the vast expanse of the shallow waters that comprise the Bahamas that it is best developed. The Florida Keys, particularly along the border of the warm Florida Current, receive many elements of the insular fauna and so form a mixing ground for continental and island species, an important factor contributing to the richness of Florida's fish fauna.

Other mixing areas are in Cuba, Hispaniola and Jamaica and along Central America from the Atlantic coast of Yucatan to Colombia. Here in coastal waters that never cool much one finds an island fauna along the reefs that fringes areas where the shelf is very narrow and estuaries absent. A continental fauna occurs in the bays and estuaries and in areas of broad shelf where muddy habitats are common.

In this regard most of the southern and western shores of the Caribbean present a mixed faunal picture. Sediment laden waters pouring from the Rio Atrato into the Gulf of Uraba move over the saline Gulf waters and deflect eastward until they get far enough offshore to get caught in western currents. One finds along the eastern shore of the entrance to the mouth and for a long distance along the continental slope an organic sink of deep sulphide swelling muds filled with plant and animal debris from the Rio Atrato.

On the shelf east of the entrance to the Gulf of Uraba we find sciaenids, clupeids and engraulids, all characteristic of the southern continental fauna. To the west of the entrance of the Gulf of Uraba we find a hard sand bottom rich in sponges and corals with a characteristic, species-rich, insular fish fauna.

The island fish fauna may be contrasted to the continental fish fauna in the same way that one compares a tropical forest to a temperate forest. Thus like the tropical forest there are many species, often very specialized, with no one really dominant whereas the tropical continental fish fauna, though with many more species than its temperate counterpart, has fewer species and with clear dominants. In the Gulf of Uraba for example we made haul after haul with a try-net with almost all of the catch consisting of the lane snapper (Lutjanus synagris) and the bumper (Chloroscombrus chrysurus). Similarly on the muddy shelf east of Uraba the total catch in a 40-ft trawl was dominated by the few species of sciaenids, clupeids and engraulids already mentioned. In contrast west of Uraba where the insular fauna reaches the Panamanian shore, trawl hauls contained in the main 20-30 species of many families, each about equally represented.

This faunal diversity and this distribution pattern which includes so much of the shore waters of the tropical western Atlantic has important implications for the fisheries for it means a fishery dependent not on a few species but on a wide variety of species that are variously marketable. We will return to this topic later.

Within the insular province we find many curious discrepancies in distributions: absences of species from islands that should have them, curiously disjunct distributions. When this problem first arose it was suspected that some geographic answer might emerge. As more areas became well studied any possibility of geographic solution disappeared. Intensive studies of the biology of reef fishes were started at Miami and information gained from these studies have supplied the answers.

First, if there is one characteristic feature of the insular fauna it is the vast coral reef habitat. The complexity and diversity of this habitat and its fish fauna have interested me for some time and the understanding of this fish fauna provides the key to the understanding of the distribution of fishes within the entire island province.

The underwater movies of reef fishes that we have grown accustomed to see typically show clouds of fishes milling about the ledges and crevices of the reef itself parting to allow passage of the swimmer to close behind him. In the western Atlantic these clouds are composed in the main of grunts of the genus *Haemulon* (family Pomadasyidae) and snappers of the genus *Lutjanus* (family Lutjanidae). Geographically these fishes, all of the island region, reach the Florida Keys for example. Why then the scarcity or absence of some species from scattered islands through the range? Studies show that each of these species is nocturnal in habit and that they range widely at night to reach their feeding grounds on the broad sandy and grassy flats adjacent to reefs. They depend on the reef for shelter during the day. A study of island areas where such species are absent invariably has shown a steep underwater profile, frequently with profuse development of fringing reefs but with very little flat area between the reefs and the shore. In short, such islands do not provide the necessary range land for these animals to make a living. Thus such species, though able to reach these islands on a regular basis, will never become established there.

Therefore, within the insular province we can say that those island areas with reduced shallow-water environments near the reefs will have an impoverished fish fauna, such impoverishment largely compromising the nocturnal reef species that leave the reef to feed over these flats by night. Conversely, in island areas with broad flats but little reef development such fishes may be established by providing shelter in the form of artificial reefs.

If there is one feature that characterizes the true reef fishes it is the abundance of species that feed on plankton by a process of selection of individual plankters from the water column. At least one eel (*Nystactichthys*), most cardinal-fishes (*Apogon*), bonnetmouths (*Emmelychthydae*), jawfishes (*Opistognathus*), a variety of the smaller seabasses (*Liopropoma*, *Serranus*) are but a few of the many reef fishes that practise this food gathering habit either by day or night. Within the insular province they are restricted to the upstream sides of the better developed reefs, reefs washed by steady and plankton rich ocean currents. This sizeable element in terms of number of species is to a large extent absent from such island areas as the Virgin Islands where reef development is restricted and generally poor. Poor reef development and reduced shelf area result in an impoverished tropical fish fauna from Puerto Rico through the Lesser Antilles.

Another feature of the insular fauna that needs attention is the lack of consistency in the fish fauna at a given site with time. Although upward of 500 species have been taken from one reef area, even the most intensive collections seldom yield more than 70 to 100 at any one time. Most consistent are the diurnal species that feed about the reefs, the parrotfishes (*Scaridae*), wrasses (*Labridae*), demoiselles (Pomacentridae), butterflyfishes and angelfishes (Chaetodontidae), surgeonfishes (*Acanthuridae*) and those nocturnal species that seek shelter on the reef by day, especially the grunts (Pomadasyidae), and snappers (Lutjanidae). Least consistent are the burrowers and those that dwell in the interstices of the reef itself.

Finally we should mention that the few collections available to us from the Fernando Noronha region indicate that these islands comprise a distinctive outpost of the insular fauna far to the northwest.

Excluding oceanic fishes, fisheries in the insular province will be based on a wide number of species and will continue to use for some time hook and line and a variety of traps. It is important to note that anything that reduces or destroys the reef structure itself will reduce the quantity and the number of kinds of fishes present. It is my view that the current practice of fishing with dynamite should be prohibited. Similarly, uncontrolled use of traps will result in the reductions of stocks of the larger, and from man's standpoint, the more useful reef fishes. Particularly important here is the use of very durable traps that are moved by storms or otherwise lost and which then continue to fish for long periods of time to no one's benefit. Such problems could be alleviated by providing the traps with weak links or self-destruct devices which would ensure destruction of the traps' fishing capacity within short periods of time.

4 UBIQUITOUS OR GENERALLY DISTRIBUTED SPECIES

Some fishes, particularly free-swimming predacious species but with some other types occur throughout the tropical western Atlantic and indeed variously through warm waters of the rest of the world. Here we include the great barracuda, Sphyraena barracuda, most of the carangids and such small species as the gody, Bathygobius soporator, the blenny, Blennius cristatus, and the sergeant-major, Abudefduf saxatilis.

5 THE FLORIDA KEYS-CENTRAL AMERICA DISTRIBUTION

A number of species of reef dwelling fishes occur only in the Florida Keys, and along rocky shores and islands along the coast of Central America from Cozumel Island and eastern Yucatan to Nicaragua. All presumably occur in Cuba as well. Best known of the species exhibiting this peculiar distribution is the brightly coloured neon goby, Gobiosoma oceanops, a species so well known and so conspicuous that we can state with conviction that it does not occur in the Bahama Islands or in the Cayman Islands. These fishes belong to groups insular in character.

6 BERMUDA

We have not mentioned Bermuda until now because Bermuda has a waif fauna derived both from the United States and from the Bahama Islands. It is not important to our consideration of the Caribbean fish fauna.

7 ENDEMISM IN TROPICAL WESTERN ATLANTIC FISHES

The tropical Atlantic fish fauna as a whole possesses a large number of species endemic to the region and this is true both for the insular and continental elements. Recent studies at the Institute of Marine Sciences of the University of Miami of fishes collected at Annobon and Fernando Póo, islands along the Guinea Rise, show that a number of insular species formerly thought to be restricted to the western Atlantic occur on these outposts of Africa.

8 STATE OF KNOWLEDGE

The two continental patterns and the insular pattern of distribution of shelf and shore fishes are being supported fully by increased knowledge of the distributions of individual species. Undescribed species exist for each faunal component but especially for the island province. Least known for all areas are the fishes that inhabit the deeper reefs and sea mounts from 50 m out to the upper parts of the continental slopes. Almost all species captured in a few trawl hauls of the rocky top of Arrowsmith Bank off Mexico are undescribed. Even in the Bahamas and in the Florida Keys where we now have excellent sampling, we continue to find new species with discouraging frequency. The shores of the Caribbean are least sampled of all and thorough surveys are especially needed for Cuba, Haiti, the Dominican Republic and the coastal waters of Central America.

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ANALYSIS AND DEVELOPMENT OF THE MARINE RESOURCES OF A REGION

by

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1 INTRODUCTION

In this paper, we must take exception, at the outset, to two conventions. The first is that the discussion of marine or ocean resources can be limited to biological and mineral resources of the sea. Occasionally, the limits of discussion have been stretched to include ocean space as a basis for commercial and military transportation and for disposal of waste. In fact, however, a meaningful definition of the marine resources of an area or region must also include the marine environment created by the meeting of the land and the sea - beaches, coves, estuaries, natural harbours, sea conditions, climate, and other modifications imposed by land-sea interrelationships. Thus, the physical marine environment created by the sea and its adjacent land areas is, itself, an important component of marine resources.

The second convention to which the authors take exception is the precept that exploitation and development of an area's marine resources may be usefully approached as a series of individually planned and executed studies or programmes, each dealing with a given resource. Such an approach ignores the interaction among resource uses that result in competitive, supplementary or perhaps even complementary relationships in production of goods or services, and it ignores the question of optimum resource development for social and economic purposes.

The elimination of the conventional constraints compels us, then, to state that if the raison d'être for studies of resources is economic and social growth of people, it would seem imperative that relationships among marine resources, products resulting from them, and social and economic conditions in user countries should receive simultaneous consideration. Further, marine resources are such an important part, actual or potential, of the economic base of maritime nations that nothing less than a comprehensive, multidisciplinary analysis will suffice in planning for their development.

Experience with multidisciplinary work on marine resources at the University of Rhode Island has reinforced this view. Our latest effort in this area was an analysis of marine resources as a basis for development in Southern New England. 1/ No development recommendations were made.

In the region referred to, marine activities accounted for over $ 773 million of total sales made in the area in 1966 (col. 1, Table I). This is an area in which marine-resource utilization is not extremely intensive; yet marine industries generated over 11 per cent of total personal income. It was found, also, that there are great differences in the extent to which different marine sectors generate economic activity (col. 4, Table I). Thus, no activity or industry is a priori better for an area than is another. The interaction among all activities must be analysed, then economic and social impact assayed, 2/ and finally a choice can be made which also takes cognizance of the social and economic goals of the people involved.

1/ Rorholm, Niels; H.C. Lampe, Nelson Marshall, and J.F. Farrell "Economic Impact of Marine Oriented Activities - A Study of the Southern New England Marine Region". Economics of Marine Resources No. 7, University of Rhode Island, Kingston, Rhode Island, 1967.

2/ See for example Ibid pp. 90-108

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TABLE I

Summary of Measures of Regional Economic Impact

A

Sector	Total sales	Local value added	Net exports	General multipliers
	$ 1 000	$ 1 000	$ 1 000	
1. Fish catching	25 484	17 000	0	2.96
2. Fish fresh processing	11 742	3 019	8 012	3.32
3. Fish froz. proc.	11 288	1 330	10 720	3.74
4. Fish whsl. & job.	14 544	3 719	4 375	3.41
5. Ship & boat bldg.	318 290	161 127	174 755	1.99
6. Marinas & yards	13 622	6 104	-507	2.76
7. Marine whsl. & ret.	23 529	7 081	2 234	2.75
8. Marine manufactur.	56 645	36 845	38 040	2.37
9. Const., towing, agt.	7 943	3 175	-2 615	1.97
10. Research & educ.	66 097	25 177	32 568	1.95
11. Marine military	213 443	179 660	197 541	2.73
12. Charter fishing	340	206	-296	3.07
13. Other marine	10 082	4 876	-1 295	2.68
Total or Average	773 049	449 319	463 532	2.75

B

	Personal income multiplier	Non-Marine multiplier	Business generated by export demand	Personal income generated by export demand
			$ 1 000	$ 1 000
1.	1.18	0.46	0	0
2.	1.07	0.41	27 542	8 509
3.	1.16	0.48	36 762	10 909
4.	1.09	0.47	17 171	5 267
5.	0.71	0.22	552 610	192 634
6.	0.94	0.43	4 935	1 625
7.	0.87	0.42	19 845	6 063
8.	0.95	0.32	106 437	42 544
9.	0.64	0.27	2 250	705
10.	0.62	0.28	114 594	35 114
11.	1.22	0.41	479 114	216 153
12.	1.17	0.47	794	297
13.	0.96	0.50	1 483	521
Total or Average	0.97	0.40	1 363 537	520 341

2 THE NATURE OF A COMPREHENSIVE ANALYSIS

2.1 The marine resources

A useful beginning is a physiographic and hydrographic account of the area, followed by a qualitative and quantitative description of the other marine resources. The physical description should stress the near-ocean and near-shore environment as well as land-sea interrelationships. These and other resource accounts should relate to possible uses and practical effects. For example, discussions of currents and tidal exchange should be developed with pollution and industrial thermal wastes in mind as well as the relationships to fisheries resources. Weather conditions, such as icing in temperate areas and hurricane frequency in the subtropics, should be reviewed with attention to coastal damage in the vulnerable areas. Lagoons in the tropics and salt pond estuaries in temperate areas may be assayed as natural fisheries areas, potential aquaculture areas, and environments favourable to boating and other recreational activities. An outline of the marine resources that might be covered in the review of a region should include:

- General Marine Environment
  - Climate
  - Sea characteristics and hydrography of coastal and estuarine areas
  - Shoreline and other physiographic features
  - Accessibility
  - Pollution
- Ports and Harbours
  - Shipping and processing facilities
  - Free ports
  - Shipping lanes and bunkering facilities
  - Small harbours and marinas
  - Undeveloped natural locations
- Fish and Shellfish
  - Basic production characteristics of an area [3]
  - Commercial
  - Sports
  - Unutilized species
- Extractive Resources
  - Mineral
  - Non-fish biological

2.2 Economic and social characteristics

Marine oriented activities must contribute to the social and economic goals of the countries that utilize the resources. One must also know something of the human resources that are available. It is therefore important that knowledge of general economic and social characteristics enter into the planning for marine resource use. Needed areas of knowledge are:

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[3] Describe by areas and habits (noting for example where they are estuarine or shelf forms, migratory or resident). Also discussed in the categories of natural harvests and subject to culture.

General Economy

- Employment and earnings
- Composition of economic activity
- Capital markets
- International trade

Population

- Labour force
- Education
- Health and welfare
- Social and cultural characteristics

2.3 Products or services

Having in mind the natural and human resources that are available, it is then possible to list the products or services that can be produced. It should be kept in mind that at this stage one is only to be concerned with whether or not certain products or services can be produced, not whether they should be produced. This latter question requires further analysis.

Once the possible products and services are listed, it is necessary to determine the amount of marine and other resources, as well as output from other industries, that are required to produce given amounts of products or services from the marine environment. If the enterprises are new to the area, or are largely undeveloped there, it may be necessary to adapt these technical relations from studies in other areas.

2.4 Political and social institutions

Given proper data in the above categories, it is possible to make some statements about the type of marine resource utilization which most nearly matches the nature of the resources with the goals and abilities of the population. Before final recommendations can be made, however, it is necessary to know something about the likely future private and public demand for the products or services that are contemplated. With this in hand, development decisions are possible.

2.5 Method of analysis

There are a number of methods of analysis that are suitable for bringing together the various technical, economic, and social data into a framework for decision making. One of the most useful is input-output analysis, which facilitates not only a general type of cost-benefit analysis, but in addition yields information that will shed light on the different economic impact of various enterprises and the interrelationships among previously determined social and economic factors. 4/ This was the method used in the New England study referred to above.

To reap maximum benefit from a study of marine resources, the study should be planned at the outset for use in development decisions. Further, many basic and background studies undertaken in an area can be most useful if designed to fit ultimately into the follow-up marine resources analyses. Appreciating this in advance, one can often, with little or no added costs or energies and with no relaxation of basic goals, re-shape the background studies in the interest of resource development analyses. For example, the location of plankton stations of a basic biological study may be modified to assure coverage of locales of potential interest in aquaculture, or studies of circulation in an area might be modified with attention to sites of interest in locating nuclear-powered generating plants. Thus, in planning marine studies of a region it is of utmost importance to have a strong representation of those who will ultimately be involved in critical resource development studies. This need has not been as well recognized as the need for a broad representation of physical and biological scientists.

4/ See for example: Wassily Leontief et al., "Studies in the Structure of the American Economy" Oxford University Press, New York 1953.

Of equal importance is the involvement, particularly at the planning and the conclusion stages, of representative decision makers from the region itself. There is perhaps no more fruitless enterprise than the resource development study that is initiated and completed by outside "experts" without consultation with those people in the region who are ultimately going to be making development decisions and who are going to profit or lose from the success or failure of the development they undertake.

In summary, marine resource studies must recognize that all aspects of the general marine environment are important resource components. Further, the authors firmly believe that multidisciplinary coordination of such studies, extended to include economic, social and cultural factors, is essential if marine resource development is to serve the goals of mankind in the years ahead. Finally, individuals or groups who do research on resource use must realize that optimum development will probably not take place unless people from the regions or areas involved are brought into the decision making framework when studies are initiated rather than after they are completed.

THE PRESENT STATUS OF EXPLOITATION AND INVESTIGATION OF THE CLUPEOID RESOURCES OF VENEZUELA

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1 INTRODUCTION

Venezuela has relatively productive seas along its 2 800 km of coastline and over its 90 000 km^2 of continental shelf; this productivity is promoted by the trade winds which cause upwelling. The continental shelf is about 200 m deep at its outer edge and falls rather rapidly to 2 000 m. It is about 100 km wide off the state of Sucre and about 10 km wide off La Guaira in Central Venezuela. There are approximately 90 000 km^2 of shelf within the 200 m contour which is of uniform depth except for the Cariaco Trench located between Cumaná and Higuerote, about 60 km offshore. There are three important relatively shallow gulfs: Venezuela, Cariaco and Paria.

The Guiana Current, derived from the south-equatorial current system, flows north-westward along Venezuela's eastern seaboard. The Guiana Current is bounded on its eastern side by the Equatorial Countercurrent and on its more northern side by the North Equatorial Current. On its western side it receives fresh water, especially in the rainy season (May-November) from the Amazon, Orinoco and other rivers. These waters influence the ecology of the continental shelf and nearer offshore waters.

Northern Venezuela is in the trade-wind zone and experiences wind-induced upwelling along its coastline; this markedly increases primary productivity (Curl, 1960). Ballester and Margalef (1965) have found high primary productivity in the upper 50 m between the Island of Margarita and Peninsula of Araya. High primary productivity is sometimes found in the Gulf of Cariaco; standing crops greater than 3.0 ml/m^3 of phytoplankton and greater than 800 ml/1 000 m^3 of zooplankton have been observed between December and April, when upwelling is strongest (Simpson, 1963). Off Venezuela these waters support sizeable fish stocks, many of which are commercially exploited: sardines, anchovies and tunas, in the east; various demersal fishes and shrimps in the west (Simpson and Griffiths, 1967a).

2 RESOURCES EXPLOITATION

The principal clupeoid resources are the sardine (Sardinella anchovia), rabo amarillo (Cetengraulis edentulus) and machuelo (Opisthonema oglinum).

The historical record of the exploitation of these resources is shown in Table I.

2.1 Sardine

The sardine, Sardinella anchovia, supports the most important commercial fishery in Venezuela. The fishery is conducted by beach seining, and is characterized by the abundance of sardines from about December to May, in a relatively small body of water, the Gulf of Cariaco. The Gulf is approximately 56 km long by a maximum of 14 km wide, narrowing at the entrance to about 3 km and has a maximum depth of about 90 m; most of it is much shallower. Assuming an average depth of 45 m, the total volume of water was estimated at 31 km^3 by Gade (1961a).

4.12

TABLE I

Total annual catches of the three most important clupeoid species and the total annual catch of all species from 1946 to 1967, in thousands of metric tons

Year	Sardine	Rabo amarillo	Machuelo	Total catch
1946	4.6			63.6
1947	4.4			64.4
1948	8.4			79.8
1949	6.7			65.1
1950	5.2			61.5
1951	10.8			63.9
1952	10.8			62.4
1953	12.4			63.3
1954	8.4			51.7
1955	15.0			68.0
1956	13.6			61.3
1957	27.3			83.7
1958	29.9			77.2
1959	30.7	1.47		83.8
1960	30.6	2.12		85.7
1961	23.4	4.51		83.6
1962	32.3	4.35		94.9
1963	35.3	4.54		97.4
1964	42.1	1.29	0.6	110.4
1965	43.8	4.79	0.8	119.3
1966	39.1	2.08	3.6	116.8
1967	39.8	0.86	5.1	113.2

The sardine fishery is conducted by beach seining and the annual catch has averaged about 40 000 tons over the past five years. Most of the catch is normally taken in the Gulf of Cariaco which is an important spawning area. About 400 sets are made annually with an average catch per set of about 100 tons (Griffiths and Simpson, 1968).

About 80 percent of the catch is usually made in the Gulf; the rest is taken along the west coast of the Peninsula of Araya and around the Gulf of Santa Fe. Sometimes catches are made along the north coast of the Peninsula and around the Islands of Margarita, Coche and Los Lobos. However, this seasonal pattern of abundance has been markedly different during 1965 and 1966 when the greater part of the annual catch was obtained between June and November.

One beach seine set usually catches the whole school. Although schools of more than 400 tons have been taken in one set, about 59 percent of the schools are less than 100 tons and 91.5 percent are less than 200 tons (Simpson, 1963).

The fishing effort, as measured by the number of sets, is given in Table II. These figures are comparatively reliable, since they were obtained from the factories which record the arrivals of fish each day from specific seines. However, in recent years the proportion of seines owned and operated independently has increased, whereas in earlier years they were nearly all owned by, or contracted to, specific factories. This means that an independent seine fisherman may sell to more than one factory, though in general this would not be from the same set.

From the previous years it can be seen that the percentage of multiple sets is on the average somewhat less than 6 percent.

By computing the catch per set from the catches made by single sets only and the same index from global totals of catch and effort, the above-mentioned discrepancy becomes apparent in recent years (Table III).

TABLE II

The number of single and multiple beach seine sets
and their total from 1957 till 1966

Year	No. of single sets	No. of multiple sets	Total
1957	244	20	264
1958	232	15	247
1959	251	9	260
1960	315	14	329
1961	266	14	280
1962	273	15	288
1963	333	20	353
1964	369	48	417
1965	301	14	315
1966	353	23	376

TABLE III

Average annual catch of sardines (metric tons) in Venezuela
from 1957 till 1966, computed from the results of single sets
only and from those of single and multiple sets
(global totals of catch and effort)

Year	Catch per set (single)	Catch per set (global)
1957	105	90
1958	133	126
1959	107	119
1960	86	93
1961	78	84
1962	107	112
1963	88	100
1964	79	100
1965	85	139
1966	80	104

Although the nets are of two main sizes no standardization of the unit of effort has been undertaken because there is no real difference in efficiency since the whole school is usually captured, irrespective of net size. The introduction of outboard motors to assist setting the seine has produced a trend to larger nets.

It can be seen that catch and effort have increased steadily during the last decade and that the catch per set has shown no pronounced tendency to decrease or increase.

In the Gulf of Cariaco, more sets are made on the north side than on the south side. Upwelling, however, has been shown to be more pronounced in the southern and eastern parts of the Gulf (Gade, 1961b; Griffiths and Simpson, 1967a). On the west coast of the Peninsula of Araya, the southern part is generally more heavily fished. Along the Santa Fe coast, the more intensively fished areas are the Gulf of Santa Fe (in many ways a miniature of the Gulf of Cariaco), Isla Caracas and the Bay of Mochima. There has been a marked increase in fishing along the north coast of the Peninsula of Araya, especially west of the Island of Caribe, though also to the east, during the last two years.

Historically, most of the catch has been taken in the early months of the year, but occasionally this pattern shifts somewhat to the middle and sometimes the later months of the year.

The causes of annual variations in the peak fishing months which are usually from January to April are at present unknown, but certain pertinent facts may be mentioned.

4.12

The Gulf of Cariaco is an important sardine spawning area (Simpson, 1963; Simpson and González, 1967). Although some spawning occurs throughout the year, the main spawning season is from December to April, and the peak spawning is usually during January and February. The highest monthly catches are usually taken during the main spawning season and annual variations in the timing of peak spawning may be reflected in the timing of peak catches.

In the Gulf of Cariaco, upwelling is most intense from December to April, and is induced principally by the north-easterly component of the trade winds; these are strongest during the early months of the year and are weaker and more variable during the later months, often being replaced by winds from the north-west. Griffiths and Simpson (1967a) have shown, at least for 1960 and 1961, that there can be significant annual differences in the intensity and duration of upwelling in the Gulf of Cariaco; these may also determine the availability and/or abundance of the sardine and the distribution of monthly catches.

A knowledge of regional migrations is required for planning the best fishing strategy. There have been reports of a shortage of sardines for over a decade now, yet the catch has increased from 23 700 tons (1957) to 43 800 tons (1965), and the amount of effort (number of sets) increased from 264 to 397, respectively. The reported shortages may, therefore, be strictly seasonal and due to the migrational pattern.

Catch per unit of effort is commonly used as an index of average apparent abundance, and the catch per set is provisionally considered to be the index for this fishery. In most of the sets the whole school is captured (Simpson, 1963), so that, in effect, school size becomes the index of abundance. However, the most important factors governing school sizes are not known. As real abundance declines, school size may remain independent of stock density and, therefore, provide a false measure of apparent abundance. Under the passive conditions of this fishery, the total catch or total effort may be a better index; the latter would be especially useful if the frequency with which schools approached the shore depended on stock abundance. From 1957 till 1961 the frequency distributions of school size showed little change. It is premature to conclude from these data that school size is independent of stock abundance, but this seems likely at present stock levels.

The present fishery, though using a primitive method, is in some respects a comparatively efficient one; the average catch per man per year is about 200 tons (Schneider and de Leon, 1960). Using this fishing method the only practicable means to increase the catch substantially would be to fish the resource throughout a greater extent of its distribution along the coast. Nevertheless, the same sort of limitation subsequently presents itself, since it exploits only the periphery of the resource and is limited by the low accessibility of the schools. With increasing demand it seems inevitable that more modern and mobile fishing gear will replace the beach seine. Some experimental purse seining to exploit the sardine when offshore has been done; however, the results have been modest. This may be partially due to inexperience with this method, but it may also be due to the behaviour of the sardine schools which are often diffuse and rather deep when offshore. It may be necessary to introdúce purse seining using lights to concentrate the sardines.

2.2 Anchovy (rabo amarillo)

Known locally as the "rabo amarillo", this species (Cetengraulis edentulus) is found discontinuously along the eastern coast of the Americas from Mexico to Brazil (Hildebrand, 1943; Whiteleather and Brown, 1945; Schultz, 1949).

In Venezuela the rabo amarillo has a discontinuous distribution from the Gulf of Venezuela to the Gulf of Paria; it is also found around the Islands of Margarita and Coche. Occasionally, rabo amarillo have been reported from the Gulf of Cariaco.

In August 1962, exploratory surveys were made of the Gulf of Paria and the Orinoco River mouths; in the latter region concentrations of rabo amarillo were found.

The rabo amarillo is also caught by beach seine, mostly within a few miles of Taguapire on the north coast of the Peninsula of Araya. There is no closed season, but about 95 percent of the catch is made between May and November (the rainy season, when the sardine fishery is usually less intense).

It was first exploited commercially in 1959 when 1.47 thousand metric tons were caught; the maximum catch to date of 4.79 thousand metric tons was obtained in 1965 (Table I).

The current national market for fish meal is estimated at about 20 000 tons, and the present production, which is obtained from sardine offal, tuna offal, machuelo (Opisthonema oglinum) and several species of catfish (Ariidae spp.), in addition to the rabo amarillo is about 4 000 tons. It is expected that a more intense exploitation of this species will be developed to supply the expanding internal market for fish meal.

We need to increase our knowledge of the distribution and abundance of the anchovy, not only to make the importation of fish meal unnecessary but to develop its use as bait for tuna fishing by longliners that operate from Venezuelan ports.

2.3 Machuelo

The common name of this species (Opisthonema oglinum) is the "machuelo". It is distributed discontinuously along Venezuela's coast from Lake Maracaibo to the Orinoco Delta. It is abundant in the Gulf of Santa Fe, around the Islands of Margarita, Coche and Cubagua, and along the north coast of the Peninsulas of Araya and Paria. It is taken by beach seine and cast nets and is used as bait or consumed locally. In 1966 its use for fish meal was greatly increased, causing a notable increase in the catch to a total of 3 572 tons (Table I).

It has not yet been the subject of a resource evaluation programme.

3. RESOURCE INVESTIGATIONS

3.1 Sardine

3.1.1 Taxonomy of the sardine

The fishery is principally based on Sardinella anchovia. There is, however, a small and variable component of a second "type" present in the area which is larger and deeper bodied, though in other respects similar (Simpson, 1963). Its presence in the commercial catches was also noted from a study of the scales which showed that this second "type" had a different growth rate from that of Sardinella anchovia (Heald and Griffiths, 1967).

The taxonomy of the genus Sardinella in South America waters is rather incomplete, based mainly on small samples from Brazil and Trinidad, but none from Venezuela (Hildebrand, 1963). Three species of this genus are given by Hildebrand (1963); they are S. anchovia, S. brasiliensis and S. pinnula. These three are very similar in their general appearance.

Silva (personal communication) compared various characteristics of sardines of the same genus from Brazil, Guyana, Trinidad and northern Venezuela with those given by Hildebrand for the three abovementioned species, and found appreciable discrepancies in respect of some of the characters, in spite of having limited his observations to fish within the size ranges covered by Hildebrand. Since Hildebrand used a comparatively small number of specimens, and none from northern Venezuela, some doubts remain over the taxonomy of this genus in Venezuelan waters.

However, the consensus is that the predominant species in the Gulf of Cariaco at least is S. anchovia.

The degree of taxonomic differentiation of the second type whose presence was also revealed by a study of the scales is still uncertain.

Nothing is known of the population structure of the sardine in Venezuela, though they occur both in eastern and western Venezuela. The problem of determining whether more than one population exists should be resolved using tagging and the more advanced biochemical and serological techniques, as well as morphometric and meristic analyses.

3.1.2 Early life history

The dimensions of 50 eggs (of all the embryonic stages, except stage 1) from each of 50 samples taken during February 1960 were measured and the following description is from this material (Simpson and González, 1967).

4.12

The egg is spherical with a thin, unsculptured, translucent membrane, of mean diameter 1.110 mm, with a range in this dimension of 1.060 to 1.138 mm; the range in diameter of individual eggs was 0.942 to 1.274 mm. There is a wide perivitelline space which has a mean width of 0.292 mm, with a range of 0.138 to 0.386 mm; the size of the perivitelline space increases as embryonic development proceeds. The yolk mass is spherical and the yolk granules are irregularly shaped. One large oil globule often with several (usually three) small oil globules nearby, is situated at the vegetal pole. The large oil globule has a mean diameter of 0.145 mm with a range in this dimension of 0.136 to 0.161 mm, and a range in size of individual oil globules of 0.083 to 0.194 mm. There is no pigmentation of the yolk or the oil globule; pigmentation of the embryo begins during stage VII.

The occurrence of recently-spawned eggs in samples taken throughout the twenty-four hour period demonstrates that diurnal spawning is continuous. However, a peak in diurnal spawning is indicated by the predominance of pre-cleavage and early-cleavage-stage eggs between about 19.30 and 23.60 hours.

The embryonic development of the sardine has been elucidated and resembles those described for sardine species from other regions of the world (Simpson and González, 1967).

Juveniles of length less than 100 mm were obtained by beach seine, cast net and dip net from the west coast of the Peninsula of Araya; from the coast of Santa Fe; and from the Gulf of Cariaco and north coast of the Peninsula of Araya. These samples indicated that sardines greater than 50 mm in length are present throughout the year.

The spawning season has been studied by classifying the stages of sexual maturity of the ovaries on their external appearance and by noting the occurrence of planktonic eggs. Although spawning is continuous throughout the year in the Gulf, most occurs between about December and April with a peak during January and February. These data indicate small annual variations in the time of onset and duration of the main spawning season.

Spawning in the Gulf of Cariaco was also studied by noting changes in abundance of planktonic eggs at a bi-weekly oceanographic station occupied at 10° 30'N, 64° 00'W. During the 1959-1960 season, spawning had already begun in November when the first sample was taken, reached a peak during January and remained quite heavy till April, after which it declined abruptly. Although no eggs were sampled from May till October 1960, the presence of a small percentage of ripe females in the commercial fishery showed that some spawning occurred during this period.

Examination of the samples taken during plankton surveys made along the north shore of the Peninsula of Araya showed that sardine eggs were present during September, November, December, January, March, and April.

The spawning areas are now being further delineated by plankton surveys.

Eggs were found in abundance throughout most of the northern part of the Gulf of Cariaco during plankton surveys, made during February and March 1960; most of the schools of ripe fish caught by the commercial fishery are taken in this region.

Plankton surveys made along the north coast of the Peninsula of Araya between Punto del Castillo and Morro de Chacopata during December 1959, September 1960, January and October 1961, showed the occurrence of sardine eggs in this area.

A survey made around the Islands of Margarita, Coche, Cubagua, Los Lobos and Caribe during March 1962 showed intense spawning to the north of Cubagua, to the south-west of Coche, and along the east coast of the Island of Margarita where it was most intense south of Porlamar, north-east of Pampatar, and in the vicinity of Cabo Blanco.

In early April 1962, the inshore area from Morro de Chacopata to the extremity of the Peninsula of Paria (Punta Piedras) was surveyed, and eggs were found only in the region of Tres Puntas.

The spawning area is most probably more extensive than that known, and to delimit further and more precisely the temporal and spatial distribution of spawning sardines, egg surveys are now being effected.

The sardine in the commercial catch has a sex ratio of about 1:1, based on 33 000 specimens taken between 1957 and 1960 (Simpson, 1963).

3.1.3 Growth

The commercial catch has been sampled since 1966 and length-frequency histograms drawn for each month. These histograms often show several modes with substantial overlap between modes. The data have been recast by sub-areas and are now providing more amenable to analysis by the selective grouping of modes on a monthly basis. Their temporal progression provides an estimate of the growth curve.

Scales have been mounted on glass slides or preserved since 1966, and a study was made in 1965 of some of this material. The results have been reported by Heald and Griffiths (1967) and are as follows: Two kinds of scales were found and are considered to come from two types of Sardinella.

The cumulative growth curve of S. anchovia was derived from back-calculated lengths of all fish at each age. Mean values of length at the time of formation of each annulus were calculated for separate year-classes, and were combined to produce an average growth rate.

Female sardines appear to grow slightly more rapidly than males. At the time of formation of their first annulus they have reached a length of 139 mm; at the end of the second year they are 167 mm long; and by the end of their third year they reach a length of 180 mm. Males reach 137 mm, 166 mm, and 177 mm at ages one, two and three, respectively.

Few four and five-year-old fish were found, hence it would be unwise to place too much emphasis on calculated lengths of fish more than three years old. For completeness, however, they are included in the growth curves.

The von Bertalanffy equation has been used to describe the growth and the parameter values obtained are: L_∞ (24 cm); K (0.7); W_∞ (137 g).

A smaller number (less than 2 percent) of the fish exhibit a growth rate somewhat different from the majority. Their growth pattern conforms to the dominant one till their third year. Rapid growth appears to occur between the formation of the second and third annuli, with the result that, when taken by the fishery close to the time of formation of their third annulus, they are larger than the rest of the population. The growth rate of the few which survive for a fourth or fifth year is still slightly higher than that of the normal population.

The supposition that a second group of fish (which may be another species) occurred in some samples is based on differences in the morphology of the scales. This tentative conclusion was strengthened when growth rates were estimated from the scales and marked differences were noted between the two groups.

The second type of scales differ slightly from those of S. anchovia in shape and in degree of ornamentation. They are also more transparent than the scales of S. anchovia of comparable age.

3.1.4 Length-weight

An overall length-weight equation was computed, using data from 1957 till 1963 (Griffiths and Simpson, MS). The sexes were combined since there was very little difference between their length-weight relationships. The allometric equation ($W = aL^b$) and its logarithmic transformation were used to express the relationship between length (cm) and weight (g).

$$W = 0.00562\ L^{3.136}$$

$$\log W = \log(-2.250) + 3.136 \log L$$

This relationship is based on 48 230 sardines, in the length range 11.5-28.8 cm obtained mostly from the commercial catch and weighing between 15 and 190 g.

3.2 Rabo amarillo

3.2.1 Early life history

The following aspects of the early life history have been described by Simpson (1965).

The mean length and the mean breadth of the egg are 1.208 mm and 0.587 mm, with a range in these dimensions of 1.144 to 1.260 mm and 0.548 to 0.615 mm, respectively.

The ranges of the length and breadth dimensions of individual eggs were 1.024 to 1.385 mm, and 0.498 to 0.693 mm, respectively.

The egg is oval with a single, translucent, unsculptured membrane; there is no pigmentation of the yolk, which is markedly segmented, or of the embryo, and there are no oil globules.

The eggs, stripped from a running-ripe rabo amarillo, were similar in appearance to planktonic rabo amarillo eggs, and the dimensions of these eggs resembled those of the eggs comprising the length and breadth frequency distributions attributed to the rabo amarillo.

The difference between the diurnal period of spawning of the rabo amarillo and those of the other anchovy species results in differences in the stage of development at any particular time. These differences persist throughout the embryonic period, but are more easily discernible during the early and middle stages.

The eggs are spawned between about 02.30 and 05.00 hours and the early stage is completed at about 12.00 hours and the middle stage at about 16.00 hours. Late stages, near hatching, with the ratio of the anterior projection of the tail to the embryonic length at the end of the middle stage equal to about four-sevenths were sampled between 23.00 hours and 01.00 hours. The incubation period is, therefore, about 20 hours.

The juveniles appear to have a more extensive offshore distribution than the adults, and between January and May they are relatively scarce in the inshore waters. Juveniles between 32 mm and 80 mm in length were sampled in the area of the commercial fishery from August to January.

The sex ratio in the commercial catches is about 60 percent in favour of the females.

An estimate of the spawning season in the area of the commercial fishery was made by noting the occurrence of sexually mature fish and juveniles of 32-40 mm in length. These data indicate that spawning occurs at least from June till January.

Plankton surveys made during September, October, November, December (1960), and January (1961) showed that the egg was abundant from the beginning of September to mid-November, after which its abundance declined markedly, and only a few eggs were sampled by surveys made during mid-January 1961.

The pre-cell to the 16-cell stage eggs were found along the north shore of the Peninsula of Araya in the area from Morro de la Sortija to Cautaro. The spawning area is certainly more extensive than that known and inshore surveys, from Puerto La Cruz (Anzoátegui) to the Orinoco River and around the Islands of Margarita and Coche, to delimit further the spawning area, now are being implemented.

3.2.2 Length-weight relationships

These were computed (Table IV) from observations on rabo amarillo obtained from the commercial catches for males and females separately for the years 1959 to 1962 inclusive (Simpson and Griffiths, MS).

TABLE IV

Annual length-weight equations
Y = weight in g; X = length in mm

Year	Males	Females
1959	$Y = 0.000004769X^{3.148}$ $\log Y = -5.316 + 3.148 \log X$	$Y = 0.000002254X^{3.301}$ $\log Y = -5.647 + 3.301 \log X$
1960	$Y = 0.00002512X^{2.814}$ $\log Y = -4.600 + 2.814 \log X$	$Y = 0.00000639X^{3.094}$ $\log Y = -5.1945 + 3.094 \log X$
1961	$Y = 0.00000776X^{3.061}$ $\log Y = -5.110 + 3.061 \log X$	$Y = 0.0000052X^{3.14}$ $\log Y = -5.2838 + 3.14 \log X$
1962	$Y = 0.000003875X^{3.1978}$ $\log Y = -5.4117 + 3.1978 \log X$	$Y = 0.000001786X^{3.3569}$ $\log Y = -5.7481 + 3.3569 \log X$

3.2.3 Population structure

A study of the meristic characters (dorsal fin rays, anal fin rays, vertebrae, gill rakers on the first branchial arch and number of scales in a longitudinal line) of the rabo amarillo was made by Silva (1967). This study showed statistically significant differences, the most notable ones being differences between the samples from the Gulf of Paria and the remaining localities for anal fin rays and gill rakers. Some localities of the Gulf of Paria differed from the others in respect of dorsal fin rays, but the number of vertebrae was homogeneous for all the areas studied.

It was concluded that on the average the anchoveta of the Gulf of Paria have a larger number of anal fin rays, gill rakers, and scales, and a smaller number of dorsal fin rays than those from other areas.

These differences may be due to the environmental conditions of the Gulf of Paria which is much more strongly influenced by the outflow from the River Orinoco which causes changes in the ecology of the Gulf, especially in respect of salinity.

4. ENVIRONMENTAL CONDITIONS IN THE GULF OF CARIACO

Environmental conditions in the Gulf of Cariaco were studied over a two-year period from August 1959 till August 1961 by observations taken at a fixed station (10° 30'N, 64° 00'W) on temperature, salinity, dissolved oxygen, at several standard depths, and phytoplankton and zooplankton standing crops. These observations were supplemented by: line-of-stations surveys made along the axis of the Gulf (vertical distributions of temperature, salinity and oxygen) during January and February 1961, and sea-surface temperatures obtained from a continuous recording thermometer installed on the pier at Puerto Sucre.

About four miles from the mouth of the Gulf there is a sill with a limiting depth of about 60 m. Inside the sill, the Gulf has a maximum depth of about 90 m with approximately 20 percent of the water lying below 50 m. Because the water below the sill depth is not in direct communication with that at a similar depth outside the Gulf, it will stagnate if not replaced at intervals; this occurs during certain periods of the year.

The wind system evidently affects the content of dissolved oxygen in the Gulf of Cariaco. Roughly speaking the bottom water at station 6 was anaerobic from July 1960 to early January 1961, and comparatively well oxygenated thereafter, till June 1961 when, presumably, a similar new period of nearly anaerobic water started.

The oxygen content in the surface waters tended to be low when it was low in the bottom waters. Peak surface oxygen values occurred when the phytoplankton standing crop was highest (in February 1960 and 1961).

In general terms the biological seasons are clear. December to March is the period of maximum north-easterly winds, oxygen content (especially of bottom waters), phytoplankton standing crop and, partially, zooplankton standing crop. It is also the season of least light penetration.

August to November is the period of minimum north-easterly winds and maximum north-westerlies, minimum oxygen content (especially of bottom waters), minimum phytoplankton standing crop in later months, but not in the earlier ones, minimum zooplankton standing crops, particularly in the earlier months, and intermediate light penetration.

4.1 Fertilizing mechanism

The driving force of the seasonal changes observed in the Gulf of Cariaco is the wind system. This is predominantly a system of north-easterlies which, when they relax during the (northern) summer, are generally replaced especially during August and September, by north-westerlies of somewhat lesser strength.

The north-easterlies would tend to remove surface water from the Gulf of Cariaco causing the eastward advection at sub-surface depths of water from outside the Gulf over the sill into the Gulf, and, in due course, bring that water to the surface. The narrow entrance to the Gulf would cause some piling up of water in the north-western corner of the Gulf. Any relaxation of the wind would allow a more stable redistribution (a more nearly level sea); this may explain many features of the hydrography of the Gulf that otherwise appear to obey no particular principle, for example rapid changes of temperature and salinity (Griffiths and Simpson, 1967a; 1967b).

4.12

The wind systems were examined for the period August 1959 to August 1961. In 1959 the month of minimum north-easterly wind was September. The wind strength increased steadily to a fairly broad peak in January, February and March 1960. This was followed by a more gradual decrease to a new minimum in September and October 1960. Wind strength increased in a similar manner to the previous year reaching a peak beginning in February and lasting till early in June. This 1961 peak lasted longer than the 1960 peak, a fact borne out by the difference in the period of low sea-surface temperatures, in which the 1961 period also lasted longer than the 1960 period (Griffiths and Simpson, 1967b).

The north-westerly winds reached their 1959 peak in September and declined to a minimum in January 1960. This period of minimum velocities persisted till early April when wind speeds increased rapidly to maximum values in May, which were more or less maintained, till early October 1960. As in the previous year, there was a decline to minimum values, which were observed between late December 1960 and early March 1961, when the north-westerly winds increased rapidly, well in advance of the decline of the north-easterlies. Thus, the two years 1959-1960 and 1960-1961 differ, in respect of the winds, in that the decrease of north-easterlies and the increase of north-westerlies are roughly coincident in 1961.

In discussing the sea-surface temperature distribution at Puerto Sucre, Cumaná, Griffiths and Simpson (1967b) drew attention to the noticeable differences in the season of low temperatures in 1960 and 1961, noting that in 1961 it was much longer (prolonged north-easterlies) and readily divisable into two periods, December-March and March-June, which differed in their daily temperature range; March marked the time of increase of north-westerlies well before the decline of the north-easterlies. The relation between the wind system and sea temperatures, hitherto pragmatically assumed or observed in other more general ways, was here rather precisely manifested.

4.2 Temperature

Daily changes in sea-surface temperatures at Cumaná were observed for the years 1959-60 and 1960-61.

The most notable feature about the first year (1959-60) was the drop in mean daily temperature from about $25^{\circ}C \pm 1^{\circ}C$, starting in December 1959, followed by a more abrupt increase in February 1960. The average temperature rose again to about $25^{\circ}C$, and fluctuated between 23° and $28^{\circ}C$ till September when there was a second increase to an average temperature of about $28^{\circ}C$. During the period of low temperatures (22°-$24^{\circ}C$) between December and February, the day-to-day variation was markedly reduced.

In the following year (1960-61), there was a similar drop starting at the end of December. At the beginning of October there was a drop (presumably from the high September temperatures) to an average temperature of about $25^{\circ}C$ with a slightly wider variation than in the previous year: 24°-$27^{\circ}C$ compared with 24°-$26^{\circ}C$. The descent to lower values in late December led to an average temperature of about $22^{\circ}C \pm 1^{\circ}C$. This period of low temperatures lasted much longer than in the previous year; it ended abruptly in June when the temperatures rose to over $26^{\circ}C$ in late July.

Vertical distribution of the changes in the temperature structure at station 6, from August 1959 to August 1961, were observed. The highest surface temperatures were in September, during 1959 and 1960. The thermocline (24° and $25^{\circ}C$ isotherms) remained fairly stable from September till the end of November 1959. There was some indication of a deeper thermocline (21° and $22^{\circ}C$ isotherms) during this period, and some suggestion of downward heat transfer.

Starting in December 1959 and ending in January 1960 the two thermoclines approached and intersected the surface. The upwelling ended abruptly in February 1960, and a new thermocline was formed (23° and $24^{\circ}C$ isotherms and later in April, the $25^{\circ}C$ isotherm). The thermocline depth fluctuated markedly till, in September, the thermocline appeared to split into two: the shallow part (25° and $26^{\circ}C$) remained fairly steady, the deeper part (23° and $24^{\circ}C$) descended and this vertical downward transfer of heat recurred ($24^{\circ}C$) slightly earlier than in the previous year.

The isotherms moved rapidly toward the surface in late December 1960, somewhat later than in 1959. As in 1960, the thermocline reformed and in March 1961, descended rapidly but not to a great depth; it was maintained at varying depths until July when the downward transport of heat seemed to begin, though in 1959 and 1960 this did not begin till late August or September. The upwelling in January 1961 was more intense than in 1960 and though the sub-surface temperature changes were subsequently similar to those of the previous year, the surface temperatures were generally lower.

The marked increase in thermocline depth, starting in mid-March 1961, with continuing low surface temperatures thereafter, was noticeable in the plot of sea surface temperatures at Puerto Sucre.

The contours in the horizontal surface profiles show that the flow was generally from west to east at the surface in the Gulf in August 1959 and May, August and December 1960, whereas it appeared to be mainly from east to west in November 1959 and February 1960.

At sub-surface depths the apparent flow was not so obvious. Generally, the eastward flow appeared to occur in August and, though less obviously, in November 1959 and in May, August and December 1960. Westward flow was present in February and August 1960.

Upwelling was variable in extent and degree. The usual sites were the eastern end of the Gulf (including the north-eastern and south-eastern sides), the western coast of the Peninsula of Araya and the Santa Fe coast. None was observed in the north-western part of the Gulf where warm water sometimes accumulated.

The thermocline was variable but appeared to be strongest in the later months of 1960 and in January and February 1961. It was weakest at the end of 1959 and the beginning of 1960.

The Gulf presents a complex set of conditions and appreciable or even large short-term changes are found. Indeed, the oxygen profile given by Simpson (1963) shows, in July and December 1960, for example periods of very low oxygen content in the waters of the basin of the Gulf separated for only a few days by waters of quite high oxygen content. The temperature profiles do not permit clear-cut conclusions regarding the amount and nature of the interchange of water over the sill, though attention was drawn to indications of cascading into the Trench from the Gulf. On the other hand, the fact that the water in the basin of the Gulf was often cooler than that at similar depths outside the Gulf suggested a conservative process involving little interchange across the sill at certain times.

4.3 Salinity

Observations on salinity taken between August 1959 and August 1961, permit the following conclusions:

The differences between the two years in which observations were made are substantial (1959-60 being the less complex); these differences make it imperative to keep up similar observations over a prolonged period of years to determine whether they are cyclical and to relate them to changes in sardine-fishing success.

The main factor determining the salinity distribution is advection across the sill at the Gulf entrance; this advection is almost certainly controlled by the prevailing wind system which has two main seasons that correspond more or less to the rainy (May-November) and dry (November-May) seasons and the principal upwelling season (November-May).

The type of water that enters the Gulf from the sea appears to dependent on these seasons; in the 1959-60 time-series the rapid changes mostly occurred at the changes of season; the 1960-61 conditions were much more complicated.

Two main types of water enter the Gulf, chiefly at sub-surface depths; one has a comparatively high salinity usually exceeding 36,75‰ presumed to originate from the salinity maximum (Parr, 1937), whereas the other has a lower salinity below 36,50‰ and is presumed to arise from coastal water influenced by the outflow of the Orinoco River, though Atlantic equatorial water cannot be ignored as a possible source; at certain times these become mixed to provide a water body of intermediate salinity that may fill the whole Gulf.

Local effects of rainfall are usually discernible, but are small compared with advective and mixing processes.

Local effects of evaporation are less distinguishable and much less prominent than expected, perhaps because of a possibly steady precipitation : evaporation ratio through the year.

Finally, too little is yet known of the hydrography of the Venezuelan coastal waters and their variations in time and space to permit any more complete rationalization of the complicated hydrographic events that evidently occur in the Gulf of Cariaco.

4.4 Dissolved oxygen

Observations on dissolved oxygen content are made from February 1960 till July 1961.

In February and March 1960 there was a marked "oxycline" at about 20 m depth, corresponding roughly with the comparatively weak thermocline (Griffiths and Simpson, 1967a). Some of these oxygen isopleths descended abruptly in April, ascending equally abruptly later in the same month. It is known that at this time there was an abrupt salinity change, ascribed to advection from outside the Gulf (Griffiths and Simpson, 1967b). Once the "oxycline" was re-established, between 10 and 20 m, it was weaker than in February and March and descended steadily during the first half of May, again in general agreement with the thermocline. These oxygen isopleths rose again toward the surface in the second half of May. A strong "oxycline" was re-established at about 20 m depth during June. However, a zero oxygen content was observed at the bottom early in July, but it was very rapidly replaced by (or mixed into) well oxygenated water (observed isopleths 1.0-2.5 ml/l). This water was in turn replaced by water of a much lower oxygen content late in July and early in August.

In spite of the vigorous action of the wind during January 1960, which might be expected to oxygenate the surface waters to a maximum, such peak values did not occur at the surface till late in February and throughout March 1960. This time lag might have been due to the use of oxygen to "remove" the hydrogen sulphide, or at any rate to oxygenate the stagnant bottom waters (of December), or it might have been due to a normal lag in attaining a peak in phytoplankton growth (and therefore in primary production) consequent upon the upwelling of nutrients by the strong winds.

After February, until May, the bottom waters remained well oxygenated. From about the end of March the "oxycline" became strong and stable, around 15 m depth, till the end of April when it began to fluctuate in depth and thickness.

From the beginning of May till nearly the end of June, the bottom waters were stagnant with oxygen values between 0.5 and 0.0 ml/l. An oxygen maximum occurred around 10 m depth in June; water of relatively high oxygen content occurred, however, for a brief period in mid-July down to a depth of 65 m.

After this short intrusion the bottom water was stagnant right through till early in January 1961. Except for a very brief period early in December 1960, no oxygen was detected below 60 m depth and hydrogen sulphide was present in these anaerobic waters.

At sub-surface depths, starting in August 1960, the "oxycline" had thickened, but showed marked variations in its thickness and in its depth until early October. At that time the vertical gradient became roughly linear and comparatively few variations occurred till the end of November and early December when the isopleths at mid-depths descended sharply, at once rose again, and during December fluctuated in depth in a cyclical fashion.

Beginning January 1961, the upper isopleths (3.0, 3.5, and 4.0 ml/l) which had been the chief components of the "oxycline" underwent cyclic changes in depth (between 10 and 20 m) thoughout January and February (the months of peak north-easterly winds). The bottom water became highly oxygenated, but the upwelling of the under-oxygenated water present throughout December was probably represented at mid-depths by parcels of water of comparatively low oxygen tension (1.5 ml/l).

From the end of March 1961, a sharp vertical oxygen gradient was established at about 15 m depth, which persisted till the end of May with some increase in average depth and in the variation of this depth. In May the bottom waters became low in oxygen, with values of 0.34 and 0.32 ml/l at 60 and 65 m, respectively. These low values persisted into June, when a large sub-surface maximum was formed between 10 m and 60 m depth.

The oxygen-time series at station 6 showed that influxes of oxygen-rich water varied considerably in intensity. Short-lived influxes in April, July and December 1960 were rapidly utilized. There were much greater and more persistent influxes between January and March 1961, the utilization of which was much more protracted, lasting till May 1961 before the stagnant conditions became re-established.

A vertical profile of dissolved oxygen from the line-of-stations survey was obtained on 21 January 1961. An "oxycline" was well developed in the central part of the Gulf. It sloped steadily upward to the surface at the eastern end of the Gulf, and became deeper and much weaker toward the Gulf entrance. There was a maximum just below the surface across the entrance to the Gulf. From station 6 extending toward the eastern end of the Gulf at mid-depths there was an extensive minimum probably resulting from the meridional flow of under-oxygenated water along the bottom then upward and westward (Griffiths and Simpson, 1967b).

The oxygen distribution during a line-of-stations survey was also obtained on 7 February 1961. The "oxycline" was well formed, ascending toward the surface at the eastern end of the Gulf as before. This ascent of the isopleths is taken to be a result of upwelling. No sub-surface minima or maxima were present, though there was an indication of one off the entrance to the Gulf. The water in the bottom of the basin was well oxygenated. Although the water at the extreme eastern end of the Gulf was the least oxygenated in both profiles, the oxygen tension there had increased noticeably in the period between the two surveys.

4.5 Density

Although the density of sea water is more dependent on temperature than on salinity and though the salinity range in the area of the Gulf of Cariaco is comparatively small, the results discussed by Simpson and Griffiths (1967c) (supported by previous studies on salinity and temperatures) show that, at times, salinity played an important part in determining the density distribution in this Gulf.

The time-series data showed that though the water at station 6 was, on the criterion of temperature, well-mixed (isothermal), it often showed abrupt, albeit not large, changes in salinity which were enough to produce instability in the water column. In an earlier paper (Griffiths and Simpson, 1967b) an attempt was made to ascribe a probable origin to these waters of different salinities.

The period between December and April and especially in January and February correspond to the principal upwelling period in both years. However, this period was noticeably longer in the second of the two years. These annual differences must be investigated over a prolonged period of years to determine: (i) the natural cycles, if any, in the physical properties of the environment; (ii) the effects these annual differences have on the apparent abundance and availability of the sardine stocks and other fishery resources.

Simpson (1963) showed that the periods of highest standing crops of phytoplankton coincided closely with the periods of marked domes in the pycnocline. This agrees with the generally observed phenomenon of abundant phytoplankton growth associated with upwelling.

The vertical profiles indicated that energy derived from the wind was sufficient to cause unstable conditions and perhaps to sustain them. The time-series (as well as the ones for temperature and salinity) showed very little change below about 40 m. Between 20 m and 40 m depths there was a build-up of a density maximum due to a similar one in salinity; at the same time the temperature became slightly lower. Between the surface and 20 m depth there were marked short-term variations in the depths of the isotherms, without a corresponding occurrence in the depths of the isohalines. Consequently, the isopycnals followed the isotherms in the upper 20 m.

We do not completely know the importance of these changes at mid-depths but these are where many important hydrographic events are occurring, connected no doubt with the exchange across the sill between the Gulf and the open sea. Without this exchange nearly one third of the Gulf's volume would be occupied by stagnant, deoxygenated water, and the Gulf would not provide, as it now does, the ecological basis for the abundant sardine resource.

4.6 Transparency

The Secchi disc readings, percent transmittance, the absorption coefficient (k) and the compensation depth at station 6 were obtained from August 1959, till August 1961.

The disc depth was greatest in November 1959, and least in February 1960, assuming intermediate values in the remaining months.

In the year 1960-61 the greatest values were in October and November 1960, whereas the lowest values were in February and again, in June 1961. There was, therefore, a general similarity between the two years.

The persistence of low values between February and July 1961, which is the feature that best distinguishes the two years, may be related to a similar period of persistently low temperatures in 1961 (Griffiths and Simpson, 1967a).

The estimated compensation depth at station 6, between August 1959 and August 1961, was never observed to be less than 14 m or more than 62, with an overall average of about 33 m. This implies that upwelling must move bottom water upward about 40 m at station 6 to be an effective promoter of primary production.

4.12

4.7 Plankton

A study of biological production in the Gulf is now in preparation (Simpson and Griffiths, MS).

Previous work on biological aspects of production in the Gulf has been limited to that of Curl (1960) and Richards (1960), and Kato (1961) studied some of the biochemical aspects.

The relative abundance of some of the main groups in the zooplankton have been reported by Legare (1961a). This author also made a preliminary study of the euphausids, describing five species from four genera in the Gulf of Cariaco (Legare, 1961b). The possible use of certain chaetognaths as indicators of water masses in the Gulf of Cariaco and the adjacent sea has been considered (Legare and Zoppi, 1961).

4.7.1 Phytoplankton

The phytoplankton standing crop (using the settling volume from a net haul) in the Gulf of Cariaco was observed at approximately 15-day intervals from August 1959 to August 1961.

Comparatively low values were observed between August 1959, and the end of November. In late December there was an abrupt increase to a level that was maintained till early April, the peak occurring in late February 1960. After April intermediate values were observed with peak values observed during September. This peak was finally reached in September.

From September the values descended to a minimum in November and as in the previous year, rose rapidly in December, reaching a peak again in February. Intermediate values were also observed into May (rather than in late July, as was the case in 1960). Low values were observed during June but, though the data were sparse, there was an indication of the repetition of high values observed in August and September in the previous year.

These data clearly demonstrate the seasonality in the oceanographic conditions of the Gulf of Cariaco. The peak values fall clearly within the period of maximum upwelling.

4.7.2 Zooplankton

Observations on zooplankton standing crop were taken between November 1959 and August 1961.

The index (wet volumes) of zooplankton standing crop is considered in two parts: from November 1959 till August 1960, and from September 1960 till August 1961.

In contrast to the phytoplankton the zooplankton was already at a high level at the end of November 1959, when the observations started and continued to increase to a peak at the beginning of February. There was a rapid decline to a minimum in May with some recovery during June and July, and finally a return to minimum values in August.

Thereafter, there was a steady build-up to a peak at the end of January, very much as in the previous year, though the peak was appreciably less marked. Apart from a low value in February 1961, the minimum was not reached till April and extended practically speaking through to August.

5. PRESENT LEVELS OF RESOURCE EXPLOITATION

At present levels of exploitation of the sardine resource there are no obvious trends toward smaller average fish size or much smaller catches per set, suggesting that the fishery is not endangering the resource. Current policy is to encourage more exploitation while continuing the collection and analysis of data.

The exploitation of the rabo amarillo and machuelo resources are in their incipient stages.

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ASPECTOS FISIOECOLOGICOS DE ALGUNOS INVERTEBRADOS MARINOS DE INTERES COMERCIAL PARA CUBA

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1 INTRODUCCION

Las investigaciones sobre los aspectos fisioecológicos de especies marinas de interés comercial tienen gran importancia, pues creemos que algunos problemas relacionados con las pesquerías pudieran ser parcial o totalmente resueltos sobre bases fisioecológicas.

Las zonas del océano de importancia para la pesca son aquellas que presentan características ecológicas que satisfacen los requerimientos metabólicos de determinadas especies de interés comercial, por lo cual es necesario conocer los valores óptimos del metabolismo de estas especies, a fin de facilitar la delimitación de áreas donde estén dados estos valores, para poder incorporarlas a las áreas actualmente explotadas.

Queremos agradecer al Dr. Miroslav Nikolić, experto de la FAO, por sus valiosos aportes durante la realización de este trabajo.

2 CONSUMO DE OXIGENO

Se estudió primeramente el consumo de oxígeno de algunos crustáceos de importancia comercial, obteniéndose para la langosta cubana, Panulirus argus Latreille, a temperaturas de 29°C, valores entre 69 – 73.5 µl O_2/gr/h (Buesa, MS); para el camarón blanco, Penaeus schmitti Burkenroad, a 25°C valores de 263 µl O_2/gr/h (Suárez y Xiqués, 1967); para el cangrejo moro, Menippe mercenaria Say, (ejemplares entre 34 y 410 gr) valores entre 4.33 y 22.58 ml O_2/ejemplar/h a 26°C (Karandieva y Silva, 1967); y para la jaiba azul, Callinectes sapidus Say, a 26°C valores de 60 a 70 µl O_2/gr/h (Suárez, MS).

Al observar estos datos se comprueba que en especies de mayor talla, bentónicas y de hábitos sedentarios, los valores de metabolismo son más bajos que en aquellas de hábitos no sedentarios; es evidente que entre las especies estudiadas el camarón necesita para su vida áreas más oxigenadas que las otras especies.

3 ALIMENTACION

Se llevaron a cabo experimentso con el fin de conocer el volúmen aproximado de alimento requerido por cada ejemplar, determinando la cantidad de alimento consumado por un ejemplar en diferentes unidades de tiempo por la diferencia entre el volúmen total de alimento ofrecido y el volúmen de las sobras. La aplicación práctica de estos resultados nos permitió reducir altamente el canibalismo en los estanques de cultivo.

Para estudio del balance energético de un ecosistema es necesario conocer los valores del metabolismo y de energía de cada especie; el conocimiento de esos valores es igualmente importante en los casos de aclimatación e introducción de especies a nuevas áreas, así como para su cría y cultivo en masa.

La dinámica de las raciones medias relacionadas con el peso de los ejemplares puede ser explicada en *M. mercenaria* como $r = 0.1377\ W^{0.665}$ donde r es la ración y W el peso de los ejemplares (Suchenia y Claro, 1967).

El valor nutritivo para *P. argus* es de 0.68 calorías/gr y para *M. mercenaria* (Suchenia y Claro, 1967) es de 0.55 calorías/gr; lo que representa que la alimentación con langosta es de mas contenido energético comparable con el cangrejo moro.

4 SUPERVIVENCIA SEGUN LA SALINIDAD

Se ha estudiado la supervivencia con el propósito de indagar sobre el posible comportamiento de estas especies en aquellas épocas del año en que las precipitaciones o el caudal de los ríos pudieran alterar sus hábitos, determinando una posible migración o una mortandad, o quizá una resistencia específica a estas adversidades (Suárez y Xiqués, 1967). El camarón *P. schmitti* al ser transferido bruscamente de una salinidad de $36^{0}/oo$ a una de $8^{0}/oo$, presenta una duración de supervivencia de 12 horas. Este hecho permite estimar que es posible, en el camarón, una migración o aclimatación en condiciones naturales donde la salinidad no descendería bruscamente. La langosta *P. argus* que habita aguas con salinidades de alrededor de $36^{0}/oo$, colocada en un medio con una salinidad de $8^{0}/oo$, tiene una supervivencia de solo 10 horas.

De los experimentos llevados a cabo sobre este tópico se infiere, en primer lugar, que la langosta posee un rango menor de supervivencia que el camarón, y en segundo lugar, que la captura del camarón es posible todos los meses del año en las áreas estuarinas. La esterohalinidad de la langosta determina alejamiento de esta especie de las áreas bajo la influencia de drenajes costeros durante las épocas de lluvia, y por lo tanto, su falta en las capturas.

Otra es la situación con el cangrejo *M. mercenaria*. Al disminuir gradualmente la salinidad desde $36^{0}/oo$ a $6^{0}/oo$ en un lapso de 21 días, los ejemplares de experimentación mantuvieron un régimen normal de vida, y de igual manera soportaron el aumento a salinidades mayores de hasta $45^{0}/oo$. Por el contrario, un traslado brusco a una salinidad de $6^{0}/oo$ produjo la muerte de la tercera parte de los ejemplares al final del primer día de experimentación, otros murieron el segundo y tercer día, y el resto se aclimató al nuevo medio (Karandieva y Silva, 1967). Como se evidencia para esta especie, los cambios de salinidad del agua no presentan un peligro, sean por los aportes fluviales de las lluvias o por la evaporación intensa durante la sequía.

5 ALMACENAMIENTO

El almacenamiento presenta importancia económica evidente, pués permite conocer los volumenes óptimos de agua que necesita cada ejemplar para mantener sus requerimientos metabólicos a un ritmo normal.

Para *P. schmitti*, el volúmen de agua al día es de 40 l a una salinidad de $36^{0}/oo$, y temperatura de 24°C (Suárez y Xiqués, 1967). Para *P. argus*, el volúmen de agua en corrales fijos al fondo es de 80 - 150 l, en viveros fotantes de 4 - 10 l por ejemplar, y en tanques viveros de los barcos de 5 l por langosta (Buesa, 1966).

Se ha logrado mantener langostas vivos fuera del agua durante 10 días y ostiones durante 15 días; las langostas registraron para este lapso una perdida de un 5 por ciento de peso y los ostiones ninguna.

6 RITMOS RESPIRATORIOS

Los ritmos respiratorios en langostas, denotan que poseen hábitos nocturnos, pués estos son altos durante la noche y bajos durante el día. Se ha observado en un tanque circular del laboratorio, que las langostas durante el día realizan pocos movimientos, pero de noche en la oscuridad, se encuentran constantemente en movimiento una detrás de otra formando filas.

7 SUGERENCIAS

Se recomienda el estudio de las condiciones de vida de estas especies en todos los paises del área considerado, a fin de comparar los datos y aunar el esfuerzo común en un mejor aprocechamiento de los recursos marinos, logrando así un conocimiento más exacto de la fisioecología de cada especie y su relación con el habitat.

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BIOLOGIA PESQUERA DE LA LANGOSTA
Panulirus argus (Latreille, 1804)
EN CUBA

por

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1 INTRODUCCION

Las investigaciones sobre la langosta de Cuba (*Panulirus argus*, Latreille, 1804) se basan en la orientación a una aplicación práctica, con el fin de lograr un amplio desarrollo de la pesca e industria y de tomar las medidas necesarias para la protección de este recurso. En la presente contribución, se da una síntesis de los trabajos más importantes realizados por el Centro de Investigaciones Pesqueras del Instituto Nacional de la Pesca de Cuba durante los años 1959-1968, la que reune principalmente la información suministrada por las publicaciones de Buesa (1965, 1965 a), Khandker (1964) y Peón (1961).

2 CICLO BIOLOGICO

En la época de la primavera se concentra el grueso de los individuos adultos para la reproducción y también se registra en los machos el mayor ritmo de crecimiento. En cambio, el crecimiento es de menor intensidad en las hembras sin hueva que aún conservan restos de masa espermatófora. Hembras en esta misma condición aparecen también en el mes de julio, en un porcentaje bastante alto, tal como se puede ver en el Cuadro I.

CUADRO I

Desarrollo de los estados sexuales en la langosta Panulirus argus
(en porcientos mensuales)

MESES	HEMBRAS			EN FASE ECDISICA	
	Con masa espermatófora	Con ovarios maduros	Con huevas	Hembras	Machos
I	1.4	1.9	0.6	7.8	5.9
II	3.6	10.0	3.0	7.8	9.3
III	18.2	27.0	14.8	8.7	6.4
IV	4.3	11.7	25.8	10.8	11.0
V	12.8	19.9	26.0	10.0	12.1
VI	9.7	7.4	13.6	9.2	12.3
VII	18.7	7.2	3.6	4.8	8.8
VIII	14.0	9.8	9.2	9.5	8.1
IX	11.0	2.5	1.7	10.0	10.8
X	3.8	1.2	1.0	8.1	4.6
XI	1.0	0.9	0.4	0.2	6.6
XII	1.5	0.5	0.3	7.1	4.1
III - VI	45.0	66.0	80.2	38.7	4.8

El estudio del desarrollo de los ovarios realizado en base a muestreos de hembras ha permitido obtener, al considerar solamente los datos de los ejemplares sin huevas pero con masa espermatófora, una información indirecta acerca del período de desarrollo embrionario. Por lo general, la maduración de los ovarios comienza un mes antes de la ovulación primaveral, y a medida que se acerca la época otoñal (agosto-octubre), se observa una coincidencia de estos dos procesos. Las hembras realizan durante el primer periodo de ovulación (marzo-junio) desoves consecutivos, representando el segundo un 60% del volúmen del primero. De las larvas que nacen en las aguas alrededor de Cuba, una parte se integra a las poblaciones langosteras de la región de Florida, mientras que el resto, junto con los aportes provenientes del sur (posiblemente de la región norte del Brasil) van a constituir el grueso de las poblaciones de aguas cubanas, que son para esta especie las mayores del mundo. (Buesa, 1965). Los reclutamientos de larvas se producen durante todos los meses del año, con valores máximos entre noviembre y marzo, periodo en el cual ingresan a la población el 76,6 % de los estadios puérulos. El ciclo de vida de las larvas nacidas en primavera y desarrolladas en verano es en general de 6 meses, prolongándose hasta 8 meses para aquellas desarrolladas en invierno o en áreas de poco alimento. Las postlarvas presentan un ciclo de 12 mudas y llegan al estadio 11 en un lapso de 14 meses, convirtiéndose luego en juveniles; estas últimas alcanzan la primera maduración sexual a la talla de 210 mm. de longitud total, a la edad de 4 años. En los individuos adultos, las máximas del ciclo de mudas están separadas entre si por un intervalo aproximado de 5 meses, pero ésto no significa que una langosta mude solamente dos veces al año (Fig. 1). El apareamiento y la muda ocurren en aguas someras, aquí también se concentran las postlarvas y las juveniles. Después de la maduración, los individuos adultos de ambos sexos migran desde estas aguas a regiones más profundas, en los límites del borde de la plataforma, donde las hembras ovulan y desovan.

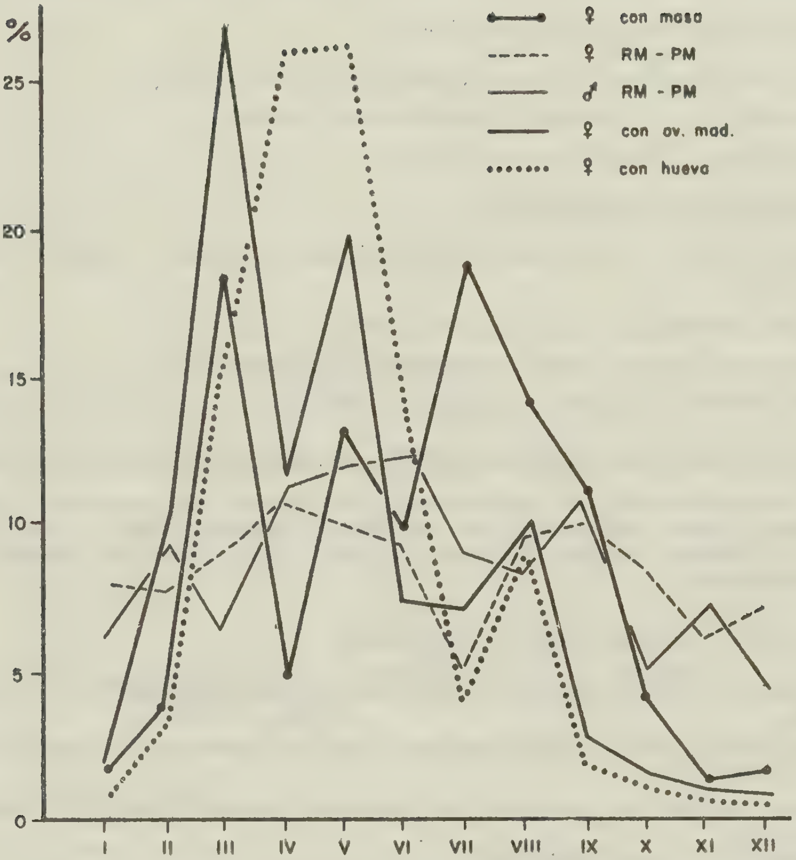

Fig. 1 Ciclo sexual de la langosta para las regiones de ambas costas de Cuba (en porcientos mensuales de los totales anuales)

3 FISIOLOGIA

3.1 Consumo de oxígeno

El consumo total de oxígeno fue determinado en mililitros de oxígeno por langosta y hora, y el índice metabólico en microlitros de oxígeno por gramo húmedo y hora. Los resultados experimentales, aunque referidos al peso en gramos, son expresados por clases de edad tal como sigue:

1 año - 1.2 ml. O_2/langosta/hora
2 años - 50 " " " "
3 años - 150 " " " "
4 años - 400 " " " "
5 años - 600 ml. O_2/langosta/hora
6 años - 810 " " " "
7 años - 1050 " " " "
8 años - 1250 " " " "

Con los datos obtenidos en la respirometría individual, se calcularon las constantes c (expresión del ritmo metabólico) y n (relación del metabolismo con la superficie corporal) por el método de los mínimos cuadrados. A continuación se dan los resultados obtenidos:

Constante	Machos	Hembras	Ambos sexos	Temperatura
c	0.204	0.140	0.185	29.2°C
n	0.808	0.908	0.847	29.2°C

Las hembras presentan mayor índice de utilización del oxígeno que los machos, pero menor ritmo metabólico, con una disminución paulatina en ambos sexos a medida que aumenta la edad (Fig. 2).

Los datos obtenidos permiten inferir que:

a) El consumo total de oxígeno está en función directa con el peso;

b) El índice metabólico es inversamente proporcional al peso; y

c) Las hembras tienen un metabolismo más activo.

3.2 Indice metabólico y temperatura

Hay una estrecha relación entre el metabolismo individual y la temperatura ambiental, de la cual es posible inferir que:

a) El mayor ritmo metabólico ocurre entre 27 y 28°C;

b) Las hembras tienen el mayor ritmo metabólico entre 28.5 y 29.5°C; y

c) El ritmo del consumo de oxígeno determina el régimen de recambio del agua.

3.3 Consumo de oxígeno y régimen de recambio del agua en relación al almacenamiento

Para los experimentos que se realizaron con vista al almacenamiento de langostas vivas, se utilizaron en total 26.604 ejemplares. Los resultados obtenidos según el tipo de almacenamiento (tanques viveros de barcas, viveros flotantes, corrales fijos), permiten señalar las siguientes recomendaciones prácticas:

(1) Almacenamiento en tanques viveros de los barcos

- a) cada langosta necesita de 2.5 litros de agua en travesías cortas a 5.0 litros en travesias largas;
- b) los ejemplares muertos, recién mudados y débiles, deben ser retirados por la mañana y al terminar la faena;
- c) se pueden mejorar las condiciones de almacenamiento utilizando tiros forzados de agua.

(2) Almacenamiento en viveros flotantes

- a) la casi totalidad del vivero debe quedar sumergida, para que se pueda aprovechar al máximo su capacidad;
- b) los viveros deben revisarse dos veces al día para retirar las langostas muertas, recién mudadas y débiles;
- c) el régimen de almacenamiento debe establecerse sobre la base de 4 a 10 litros de agua por langosta

(3) Almacenamiento en corrales fijos al fondo

- a) el régimen de almacenamiento debe ser de 80 a 150 litros por ejemplar, según las condiciones de la zona considerada;
- b) es necesario averiguar las condiciones de la zona considerada para determinar la cantidad de ejemplares a almacenar.

3.4 Consumo de oxígeno en relación con la salinidad

En los experimentos realizados se observa que al disminuir la salinidad aumenta el metabolismo, debido al trabajo osmótico que tiene que realizar el organismo de la langosta para tratar de restablecer el equilibrio iónico de sus líquidos corporales. Rebasado un cierto límite (18‰), la langosta, ya debilitada, retorna a su régimen normal de consumo de oxígeno, para después ir decayendo hasta morir.

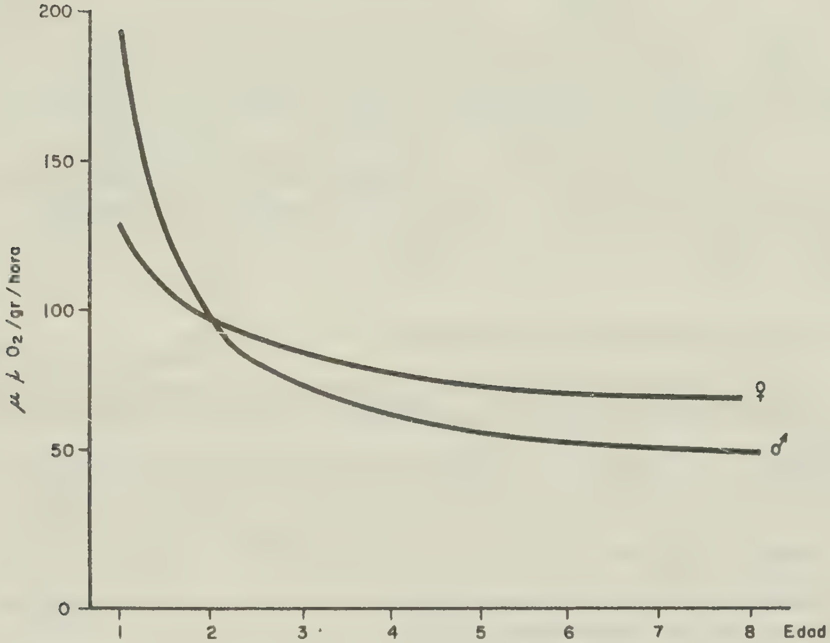

Fig. 2 **Relación entre el índice metabólico y la edad de los ejemplares por sexos a la temperatura ambiental de 29.2°C**

3.5 Ritmo de alimentación

Con respecto al balance energético de P. argus que expresa el índice de utilización de oxígeno en calorías, se ha llegado a los siguientes resultados:

a) el índice de cal/g para las hembras es constante a partir de la primera maduración sexual (4 años), pero en los machos aumenta a partir de los 6 años;

b) el balance energético es en general mayor en los machos que en las hembras, con excepción de la etapa ovulatoria al alcanzar las hembras el desarrollo sexual;

c) el valor promedio para la especie es de 0.68 cal/g peso húmedo, bastante cercano al valor de 0,88 cal/g peso seco, establecido como valor nutritivo básico para las langostas;

d) el alimento principal esta constituido por moluscos bivalvos con un contenido calórico de 0,80 cal/g peso seco; la langosta es una especie que vive en deficiencia trófica en condiciones naturales, hecho que determina su voracidad y canibalismo.

Los ejemplares adultos dejan de alimentarse cuando están próximos a mudar, pero 2 ó 3 días después comen vorazmente. Hasta los 3 años, la cantidad diaria de alimento ingerido es superior al 11% de su peso, y a partir de esta edad baja hasta un 8%. Dadas su gran voracidad y canibalismo, es difícil lograr en la langosta la evacuación natural completa del intestino para su posterior cocido y congelado, a no ser que se tenga el cuidado de retirar de los estanques los ejemplares muertos, recién mudados y débiles.

3.6 Transporte de langostas vivas

Las langostas que han de ser embarcadas vivas son tratadas con sumo cuidado, a fin de garantizar una calidad superior. Al ser capturadas, se colocan en el bote cubiertas con un saco mojado en agua de mar, evitándose así la resequedad branquial; al llegar al barco pesquero con tanque vivero, son colocadas en él, evitándose el maltrato y la exposición al sol. El mismo barco las traslada a los centros de acopio donde se mantienen hasta el momento de ser embaladas para la exportación.

Cuando las langostas son extraídas de los viveros, se evita la aglomeración en las canastas, pues se dañan las que quedan en el fondo; este proceso debe realizarse rápidamente. Luego se trasladan a neveras donde son sometidas a una temperatura de 8° a 15°C por un tiempo de 15 a 30 minutos; el piso de las neveras debe estar cubierto por sacos mojados en agua de mar para evitar cualquier contaminación con agua dulce que provocaría desequilibrios osmóticos. Al sacarlas, se depositan en cajas de cartón, colocadas en dos camadas con recortes de esponjas húmedas en agua de mar. En cada una de estas cajas, se pueden colocar hasta 15 kg de langostas. Las cajas se transportan en camiones refrigerados a 12°C hasta conducirlas al avión, donde se debe procurar una temperatura no menor de 10°C.

4 ECOLOGIA

4.1 Relaciones con las integrantes de la comunidad

Las relaciones de la langosta con los demás integrantes de la comunidad se evidencian en distintos niveles ecológicos por la acción de los predadores y la presencia de comensales y parásitos.

La especificidad de los predadores y su intensidad destructiva varían según las fases del ciclo vital de la langosta y región ecológica ocupada dentro del área de distribución. Durante el período planctónico, las larvas y postlarvas son comidas por algunos tiburones, mientras que en el período de vida bentónica, las juveniles y adultas tienen como enemigos principales a varias especies de peces (tiburones, lutiánidos, serránidos) y pulpos.

Entre los comensales, se han identificado por lo menos seis especies de epizoos por contacto continuo, las que se enumeran a continuación:

Crepidula (Janacus) unguiformis, (Mollusca Gastropoda);

Anomia simples (Mollusca Pelecypoda);

Balanus eburneus (Crustacea Cirripedia);

Lepas anatifera (Crustacea Cirripedia);

Octolamis hacki (Crustacea Cirripedia); y

Bugula sp. (Bryozoa Gymnolaemata).

Las tres primeras especies se encontraron sobre las partes duras del esqueleto de la langosta, y las tres últimas, en las partes relativamente blandas de la region neutral del abdomen.

En el grupo de los parásitos se distinguen dos tipos según la región infectada del organismo de la langosta. El primero, se refiere a ejemplares jóvenes de Contraceacum sp. (Nematoda, Ascaridae) localizadas en la cavidad estomacal y sobre las branquias, y el segundo, a quistes de Microphalus sp. (Trematoda, Microphallidae) que son esféricas, de aspecto perlado y con un diámetro de cerca de 1 mm. Los quistes se hallaron abundantemente en el tejido muscular del abdomen y la langosta parece ser en este caso un huesped intermediario.

4.2 Cadena alimentaria

La langosta es un consumidor secundario pues es un carnívoro que come herbívoros, pudiendo ser también un consumidor terciario, al comer a los carnívoros consumidores de herbívoros.

La cadena alimentaria de P. argus se inicia con organismos del primer nivel trófico, que son utilizados por los organismos del segundo nivel trófico (moluscos), los que convierten la materia vegetal en animal. La langosta, como tercer nivel trófico, se alimenta de ellos utilizando su concha y su carne; de la concha extrae el calcio que acumula en el hepatopancreas y lo necesita para la muda, principalmente en el período postecdísico.

La langosta puede nutrirse directamente de vegetales, como de algas, y también practica el canibalismo, que está muy generalizado entre ellas. Al analizar los contenidos estomacales, se encontraron en abundante cantidad exoesqueletos de su misma especie; otra parte considerable del alimento está constituida por restos de conchas de moluscos, fibras musculares y fibras vegetales de organismos no identificados.

La energía de la langosta es mayor cuando su régimen alimentario se ha iniciado a partir de los niveles tróficos inferiores que cuando su dieta se concentra desde un comienzo en carnívoros terciarios.

4.3 Distribución batimétrica en aguas cubanas

Según los datos de pesca comercial y exploratoria, se ha determinado que la distribución de la langosta se extiende hasta los 50 metros de profundidad, habiéndose reportado casos aislados de escasa captura a profundidades mayores. Es notable la disminución de su abundancia más allá de los 40 metros de profundidad.

4.4 Movimientos y migraciones

La langosta P. argus es una especie bentónica que realiza desplazamientos nocturnos, provocados en algunas circunstancias por las condiciones climáticas violentas que determinan movimientos hacia las costas en épocas de vientos del norte o en temporadas ciclónicas; los individuos presentan una dispersión al azar que parece deberse a alguna reacción fisiológica frente a determinadas variaciones ambientales. (Buesa, 1965).

Para el estudio de las migraciones se utilizaron marcas plásticas en forma de flecha, que eran introducidas en la parte dorsal del abdomen, entre el primer y el segundo segmento con una inclinación de unos 45 grados a un lado de la línea media, para no dañar el intestino. En experimentos con ejemplares mantenidos en acuario, se comprobó que la marcación no provocaba ninguna mortandad, manteniéndose la marca después de la muda en un 97.4% de los ejemplares. Las campañas de marcación llevadas a cabo se muestran en el Cuadro II.

CUADRO II

Resultados de las campañas de marcación de langostas

AÑOS	LANGOSTAS MARCADAS	LANGOSTAS RECAPTURADAS	MIGRACION EN MILLAS
1959	312	2	—
1960	677	31	0.8
1963	2929	222	18.0
1964	17884	4948	72.0
1965	3500	728	72.0
1966	—	—	—
1967	400	20	1.0
TOTAL	25702	5948	72.0

En algunos casos, las langostas se desplazaron 72 millas en 18 días; por lo general, las langostas se movían desordenadamente a razón de una décima de milla diaria, habiendo cambiado de localidad el 56.7% del total de los ejemplares marcados.

Existe un considerable grado de mezcla entre los individuos de diferentes subzonas de pesca dentro de cada zona mayor, principalmente de las zonas B y D. Estos movimientos pueden ser atribuidos a la busqueda de alimento y en algunos casos parecen ser provocados por requerimientos metabólicos.

5 POBLACIONES

Los estudios de bioestadística, a partir del agrupamiento por clases de edad, permitieron analizar el crecimiento individual y la estructura de las poblaciones.

4.25

5.1 Crecimiento en longitud y peso

CUADRO III

Comparación entre las tallas observadas y las calculadas para diferentes clases de edad desde los estadios larvales (los valores calculados, según la fórmula de Bertalanffy)

EDAD	LONGITUD TOTAL (mm)	
	Observado	Calculado
1	35	43
2	74	102
3	144	155
4	214	201
5	250	239
6	281	270
7	306	298
8	327	323
9	344	342
10	357	360
11	368	375
12	377	387
13	386	398

Para ambos sexos el crecimiento en longitud es el mismo (ver Cuadro III), es decir, no hay una diferencia entre machos y hembras. Las curvas de crecimiento calculadas según la fórmula de Ford (1933) y Walford (1946), son semejantes a las observadas por nosotros, debiéndose las variaciones a los factores ecológicos que actúan sobre el ritmo del crecimiento (ver Cuadro IV)

CUADRO IV

Crecimiento necesario para alcanzar las tallas correspondientes a las edades señaladas (longitud total en mm).

EDAD	Hasta la talla a la cual se alcanza la edad	Hasta la talla media de la clase anual	Según los datos calculados con las fórmulas de:	
	Observado	Observado	Bertalanffy	Ford-Walford
1	34	22	42	62
2	39	23	59	18
3	70	97	53	20
4	70	48	46	85
5	36	44	38	41
6	31	32	31	39
7	25	27	28	27
8	21	22	25	25
9	17	20	19	18
10	13	17	18	17
11	11	11	15	15
12	9	16	12	10
13	9	10	11	14

5.2 Composición de la población por sexos

Según las frecuencias porcentuales de las edades, las hembras de 3 a 4 años predominan en las zonas de pesca B y C; las de 4 y 5 años en la zona A y las de 3 años, en la zona D de las costas de Cuba. Desde estas edades en adelante, que es cuando se inicia la reproducción, los machos comienzan a preponderar, llegando a ser los únicos presentes en las capturas para las edades más avanzadas (ver Cuadro V).

CUADRO V

El porcentaje de hembras en el total de langostas capturadas
durante el período 1960-1966

MESES	COSTA SUR	COSTA NORTE
I	47.1	48.7
II	49.1	49.1
III	50.3	43.2
IV	47.6	49.0
V	45.5	46.3
VI	47.8	41.5
VII	48.9	43.8
VIII	48.9	42.8
IX	48.8	42.2
X	50.3	48.2
XI	52.4	47.9
XII	48.2	48.9

El predominio de los machos a partir del sexto año se debe probablemente al hecho de que las hembras tienen mayor tasa de mortalidad o a que crezcan menos y se hallan con menor frecuencia que los machos desde el momento en que alcanzan la madurez sexual. La supervivencia de las hembras es menor que la de los machos entre los períodos de la primera reproducción y las siguientes (ver Cuadro VI).

CUADRO VI

Tasas de supervivencia por sexos, desde la clase de edad
más abundante a aquella inmediatamente posterior

	Muestras totales	Capturas comerciales
Hembras		
Costa sur	0.27	-
Costa nort	0.36	-
TOTAL	0.30	0.41
Machos		
Costa sur	0.55	-
Costa norte	0.54	-
TOTAL	0.55	0.61

6 DINAMICA DE LAS POBLACIONES

Los datos sobre este tópico se han elaborado en base a los obtenidos de las pescas comerciales y exploratoria, y de las recapturas de las langostas marcadas (ver Cuadros VII y VIII)

CUADRO VII

Tasa de supervivencia (S), coeficiente de mortalidad total (Z), coeficiente de mortalidad por pesca (F) y coeficiente de mortalidad natural (M) para el período de 1963-1965 por zonas de pesca

ZONAS	S	Z	F	M	% MORTALIDAD	
					PESCA	NATURAL
A	0.52	0.48	0.34	0.14	70.8	29.2
B	0.38	0.62	0.42	0.20	67.7	32.3
C	0.56	0.44	0.32	0.12	72.7	27.3
D	0.14	0.86	0.66	0.20	76.7	23.3
TOTAL	0.41	0.59	0.41	0.18	69.5	30.5

CUADRO VIII

Tasa anual de explotación (E) y la tasa de mortalidad natural (D) por zonas de pesca

ZONAS	E	D
A	0.27	0.11
B	0.31	0.15
C	0.26	0.09
D	0.44	0.13
TOTAL	0.32	0.14

6.1 Peso de los ejemplares

Parece existir un reclutamiento constante en la region de la plataforma cubana y esto determina que el peso sea directamente proporcional a las capturas o viceversa. En años con grandes capturas, pero que presentan pesos promedios pequeños por ejemplar, el coeficiente de mortalidad por pesca (F) aumentó, llegando a alcanzar a las poblaciones con individuos de menor talla, y afectando como es de esperar las capturas de los años siguientes (ver Cuadro IX).

CUADRO IX

Peso promedio de las langostas por zonas de pesca (en gramos)

AÑOS	ZONA A	ZONA B	ZONA C	ZONA D
1960	484	515	493	437
1961	453	449	480	385
1962	468	462	505	361
1963	486	475	497	349
1964	459	453	509	394
1965	534	492	529	465
1966	465	465	520	386

6.2 Captura de equilibrio

Dentro del período de capturas anuales (1959-1968) considerado en el presente trabajo, los valores más altos se registraron en el lapso 1965/1966, con un total de 9.1 miles de toneladas métricas. Esta cantidad está ya muy cercana a la captura de equilibrio, calculada en 10.6. (Cuadro X)

CUADRO X

Captura de equilibrio (Y), captura actual, reclutas (R) y peso medio
por ejemplar en el momento de reclutamiento (Wr),
en las actuales condiciones de pesca en Cuba

	ZONA A	ZONA B	ZONA C	ZONA D
Y (miles de ton.)	1.7	7.2	0.6	1.1
Captura actual (miles de Ton.)	1.5	6.3	0.3	1.1
R (millones de langostas)	3.9	20.4	1.2	3.5
Wr (gramos)	434.5	352.3	459.2	333.6

La langosta no presenta durante todo su ciclo vital el mismo coeficiente de mortalidad natural (M), habiendo amplias variaciones desde su nacimiento hasta los 3 años de edad, que se deben a la vulnerabilidad frente al medio y a la acción más intensa de los predadores .

6.3 Poblaciones sometidas a pesca comercial

Los datos obtenidos sobre este aspecto se presentan en conjunto en el Cuadro IX, para facilitar las comparaciones necesarias (ver también Fig. 3). De la totalidad de las poblaciones langosteras de las costas de Cuba, aproximadamente una tercera parte proviene de zonas más australes mientras que el resto es autóctono.

La biomasa total de las poblaciones ha sido estimada en 31.5 miles de toneladas, correspondiendo 8.3 a las efectivas de prerreclutas y el resto de 23.2 a las efectivas comerciales. Esta biomasa representa una población total de 418.8 millones de langostas, de la cual sólo 47.8 millones de individuos adultos integran los efectivos comerciales.

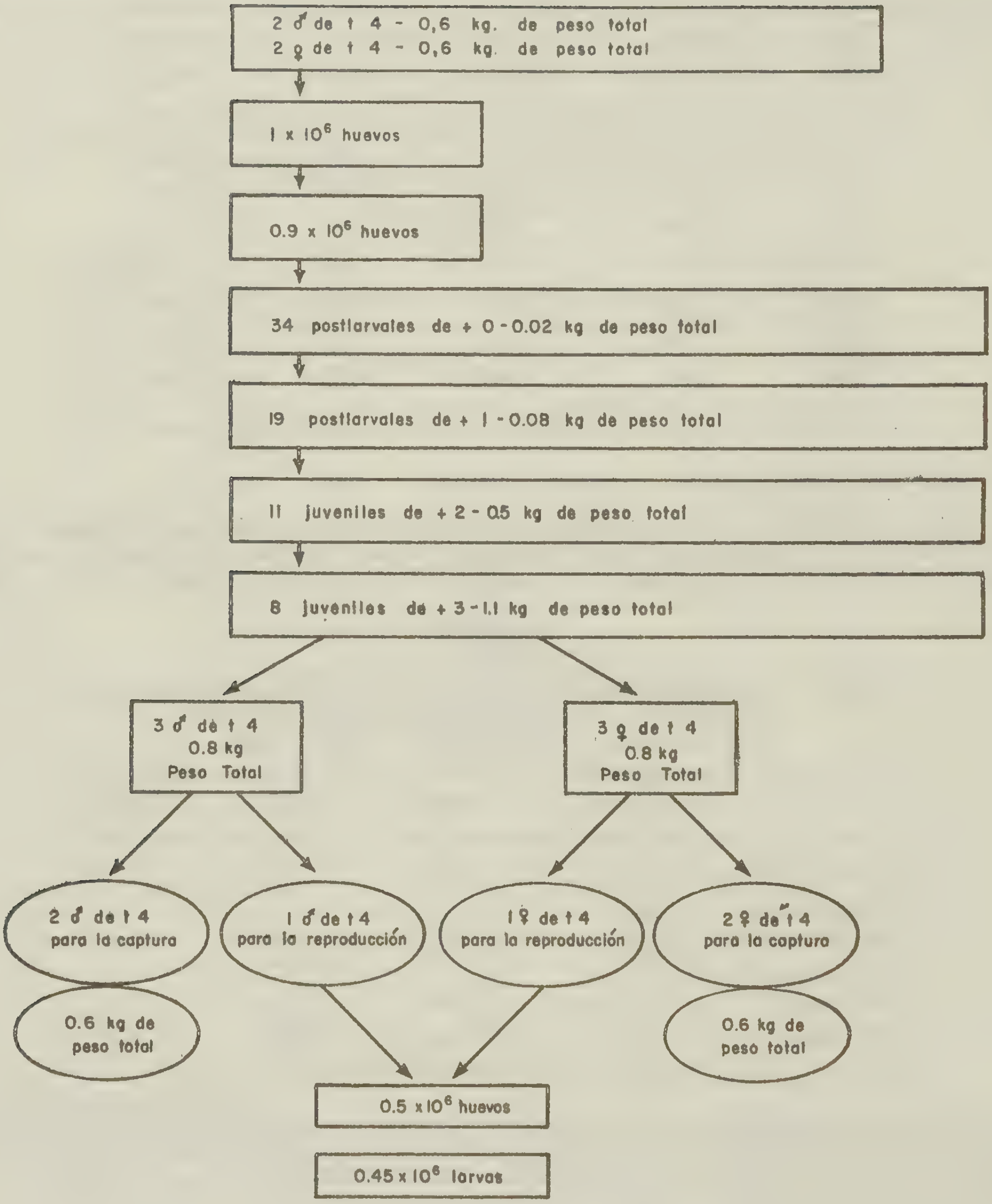
2 ♂ de t 4 - 0,6 kg. de peso total
2 ♀ de t 4 - 0,6 kg. de peso total
1 x 10⁶ huevos
0.9 x 10⁶ huevos
34 postlarvales de + 0 - 0.02 kg de peso total
19 postlarvales de + 1 - 0.08 kg de peso total
11 juveniles de + 2 - 0.5 kg de peso total
8 juveniles de + 3 - 1.1 kg de peso total
3 ♂ de t 4 0.8 kg Peso Total
3 ♀ de t 4 0.8 kg Peso Total
2 ♂ de t 4 para la captura
1 ♂ de t 4 para la reproducción
1 ♀ de t 4 para la reproducción
2 ♀ de t 4 para la captura
0.6 kg de peso total
0.6 kg de peso total
0.5 x 10⁶ huevos
0.45 x 10⁶ larvas

Fig. 3 Diágrama de la secuencia numérica del desarrollo embrionario y postembrionario, a partir del momento de la reproducción de dos parejas de langostas adultas de 4 años de edad

CUADRO XI

Resumen de los datos para las poblaciones de langosta P. argus en Cuba, por zonas de pesca

DATOS	ZONA A	ZONA B	ZONA C	ZONA D	TOTAL
(F) Coeficiente de mortalidad por pesca	0.34	0.42	0.32	0.66	0.41
(M) Coeficiente de mortalidad natural	0.14	0.20	0.12	0.20	0.18
(E) Tasa anual de explotación	0.27	0.31	0.26	0.44	0.32
(Cr) Captura por reclutamiento	0.57	0.52	0.60	0.58	-
(Y) Captura de equilibrio en miles de toneladas	1.7	7.2	0.6	1.1	10.6
(N) Población comercial en 10^6 langostas	8.1	32.9	2.7	4.1	47.8
(Y) Captura de equilibrio que puede alcanzarse en miles de toneladas	2.3	8.0	0.8	1.2	12.3
(P) Biomasa de prerreclutas en miles de toneladas	1.1	5.9	0.3	1.0	8.3
(P) Biomasa comercial en miles de toneladas	4.7	15.3	1.5	1.7	23.2
(P) Biomasa total en miles de toneladas	5.8	21.2	1.8	2.7	31.5
Larvas producidas por 10^{12} langostas	1.16	3.01	0.18	0.24	4.59
Millones de langostas de edad cero	23.3	124.9	7.1	20.9	176.2
(R) Reclutas a la pesca por 10^6 langostas	3.9	20.4	1.2	.5	29.0
(Wr) Peso promedio de reclutamiento	434.5	352.3	459.2	333.6	394.9
(q) Coeficiente de capturabilidad actual	1.26	1.31	1.45	1.18	-

7 PESQUERIAS

De acuerdo con los datos estadísticos, Cuba ocupa el cuarto lugar en la pesca mundial de langosta, siendo en general el primer país productor de langostas pertenecientes a la especie P. argus.

7.1 Capturas por años de pesca

Cada año de pesca se inicia en el mes de junio al finalizar la veda y se extiende hasta el inicio del próximo período de veda, en marzo del año siguiente.

La mejor temporada de pesca ha sido aquella de 1965-1966, debido a varios factores, entre ellos los siguientes:

a) una clase anual recluta abundante;

b) condiciones climáticas que permitieron utilizar un mayor número de días efectivos de pesca;

c) una mejor organización de las actividades pesqueras;

d) un aumento del número de jaulas y otros artes de pesca para la langosta.

7.2 Capturas por artes de pesca

Los artes de pesca, por su efectividad y distribución, capturan langostas en proporciones variables, según señala el Cuadro XII. La escasez de langostas ha llevado a los pescadores de la zona D al emplio de nasas para la captura en aquellas áreas donde la pesca manual no es factible.

CUADRO XII

Captura porcentual por artes de pesca y zonas

ARTES DE PESCA	ZONA A	ZONA B	ZONA C	ZONA D
Chapingorro	2.8	71.4	16.1	41.2
Chapingorro y jaula	-	20.0	-	-
Pincharra	83.7	-	21.8	1.1
Pincharra y jaula	-	-	32.4	-
Nasas	9.5	3.5	2.9	55.5
Chinchorro	0.1	-	0.6	-
Trasmallo	-	0.9	-	-
Bichero	-	-	6.7	-
Varios	-	4.2	11.5	2.2
No identificados	3.9	-	8.0	-
TOTAL DE ARTES MANUALES	86.5	91.4	77.0	42.3

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LARVAL DISTRIBUTION OF TUNAS AND BILLFISHES IN THE ATLANTIC OCEAN

by

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3	SPECIES COMPOSITION OF TUNA LARVAE BY AREAS IN THE WESTERN ATLANTIC	305
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1 INTRODUCTION

This report deals with the study of larval occurrences of tunas and billfishes in the Atlantic Ocean, based on data obtained from seven cruises carried out by the Japanese research vessels during 1959-1968.

Surface tows or simultaneous surface and subsurface (20-30 m depth) horizontal tows were made with a 1.4 m (diam) net or 2 m net for 15-20 minutes.

About 700 plankton samples were collected until 1967 and those obtained during the southern summer months (November through April) form the bulk of our samples.

2 GEOGRAPHICAL DISTRIBUTION

Tunas are distributed very widely in the Atlantic Ocean as well as in the other Oceans, ranging from tropical to temperate waters. Larval occurrences, however, are restricted to tropical and subtropical waters warmer than about 24°C (Figures 1 and 2)[1]. The north-south range of larval tuna is narrowed by cold water in the eastern Atlantic, whereas it is expanded by warm equatorial water in the western Atlantic. This tendency is also recognized in the Pacific Ocean (Matsumoto, 1966).

Larval distribution of billfishes resembles that for tunas and is restricted to warm waters higher than approximately 24°C (Figure 3)[1].

2.1 Albacore

Larvae of albacore (Thunnus alalunga) have been taken in the subtropical areas north of lat. 10°N in the North Atlantic and south of 7°S in the South Atlantic, and scarcely been collected in the equatorial waters. From these larval occurrences the spawning area of the North Atlantic albacore is presumed to be separated from that of the South Atlantic albacore.

Figure 4 shows the features of the spawning area of albacore in terms of the thermal structure, indicating that spawning of albacore takes place in the area where the vertical temperature gradient is small from surface through to 300 m of depth and surface water temperature is higher than 24°C.

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[1] Data of presence or absence of larvae are treated and illustrated by the 1° x 1° squares of latitude and longitude.

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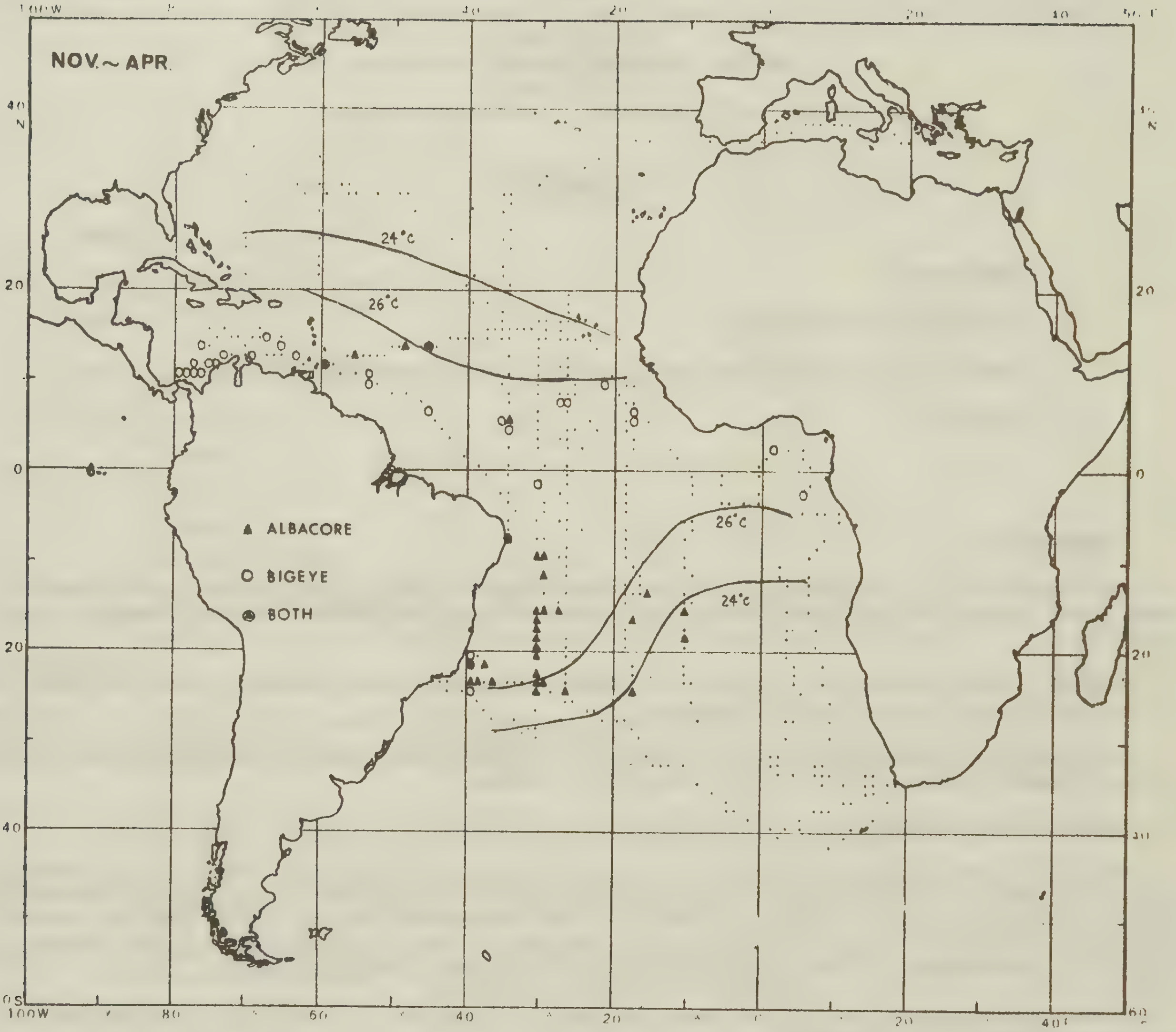
NOV.~APR.
24°C
26°C
26°C
24°C
▲ ALBACORE
○ BIGEYE
● BOTH
100W
80
60
40
20
0
20
40
40 N
20
0
20
40
60 S

Fig. 1 (a) Distributions of larvae of albacore and bigeye tuna. November–April. Small dots ... larvae absent

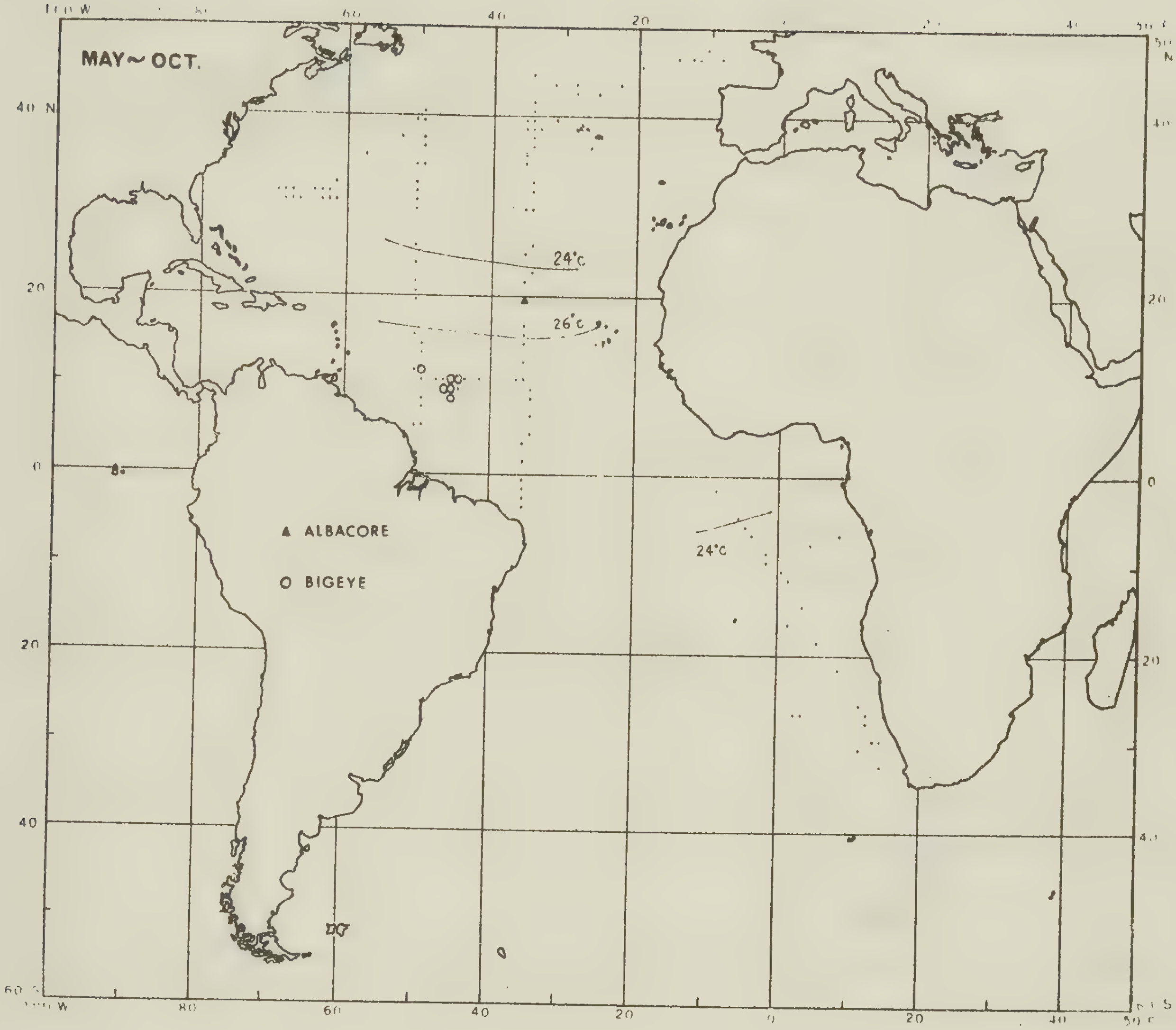
MAY ~ OCT.
▲ ALBACORE
O BIGEYE
24°c
26°c
24°c
40 N
20
0
20
40
60 S
80
60
40
20
0
20
40
50 E

Fig. 1 (b) Distributions of larvae of albacore and bigeye tuna. May-October. Small dots... larvae absent

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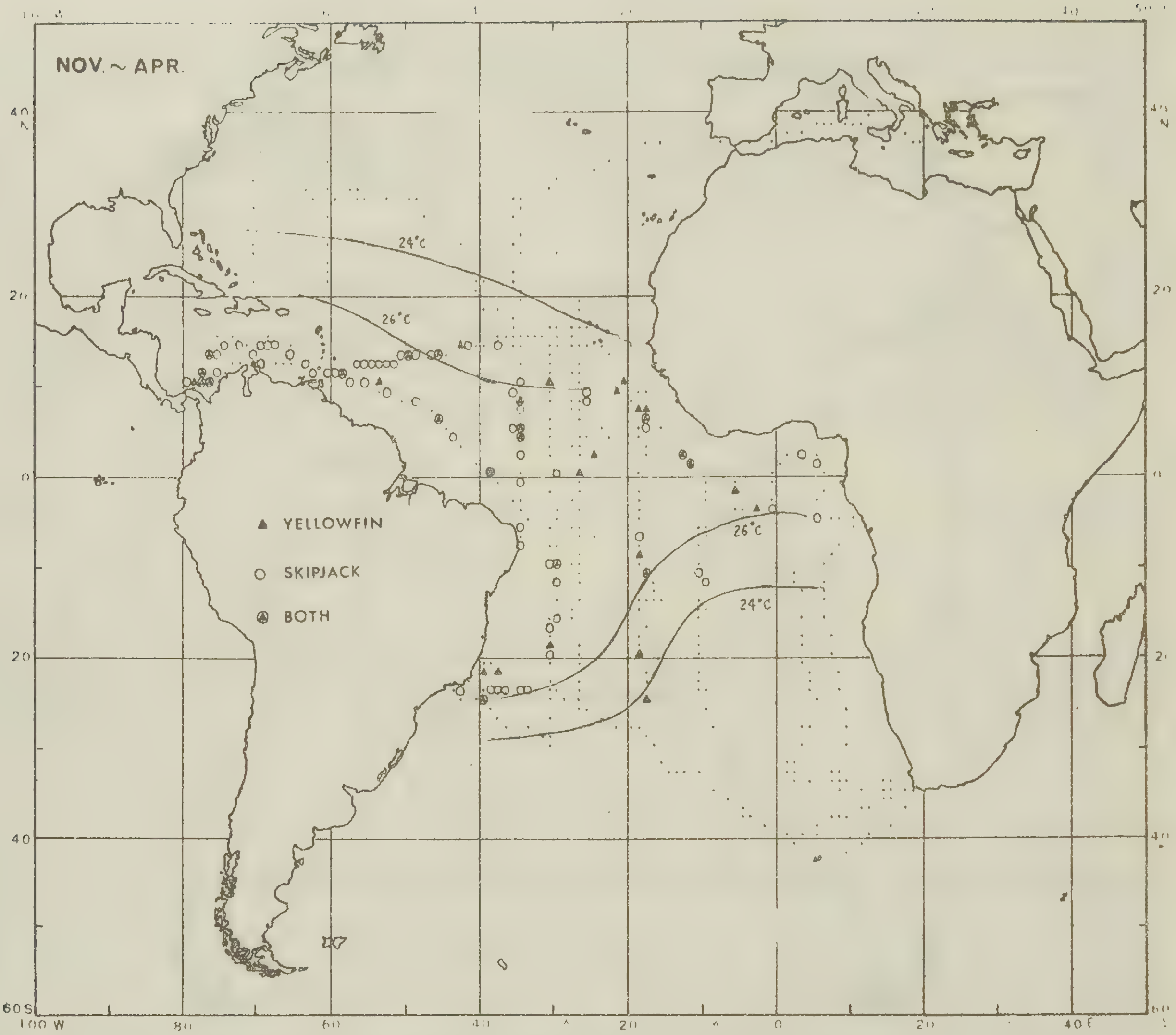
NOV. ~ APR.
24°C
26°C
26°C
24°C
▲ YELLOWFIN
○ SKIPJACK
⊗ BOTH
40 N
20
0
20
40
60 S
100 W
80
60
40
20
0
20
40 E

Fig. 2 (a) Distributions of larvae of yellowfin and skipjack tuna. November—April. Small dots ... larvae absent

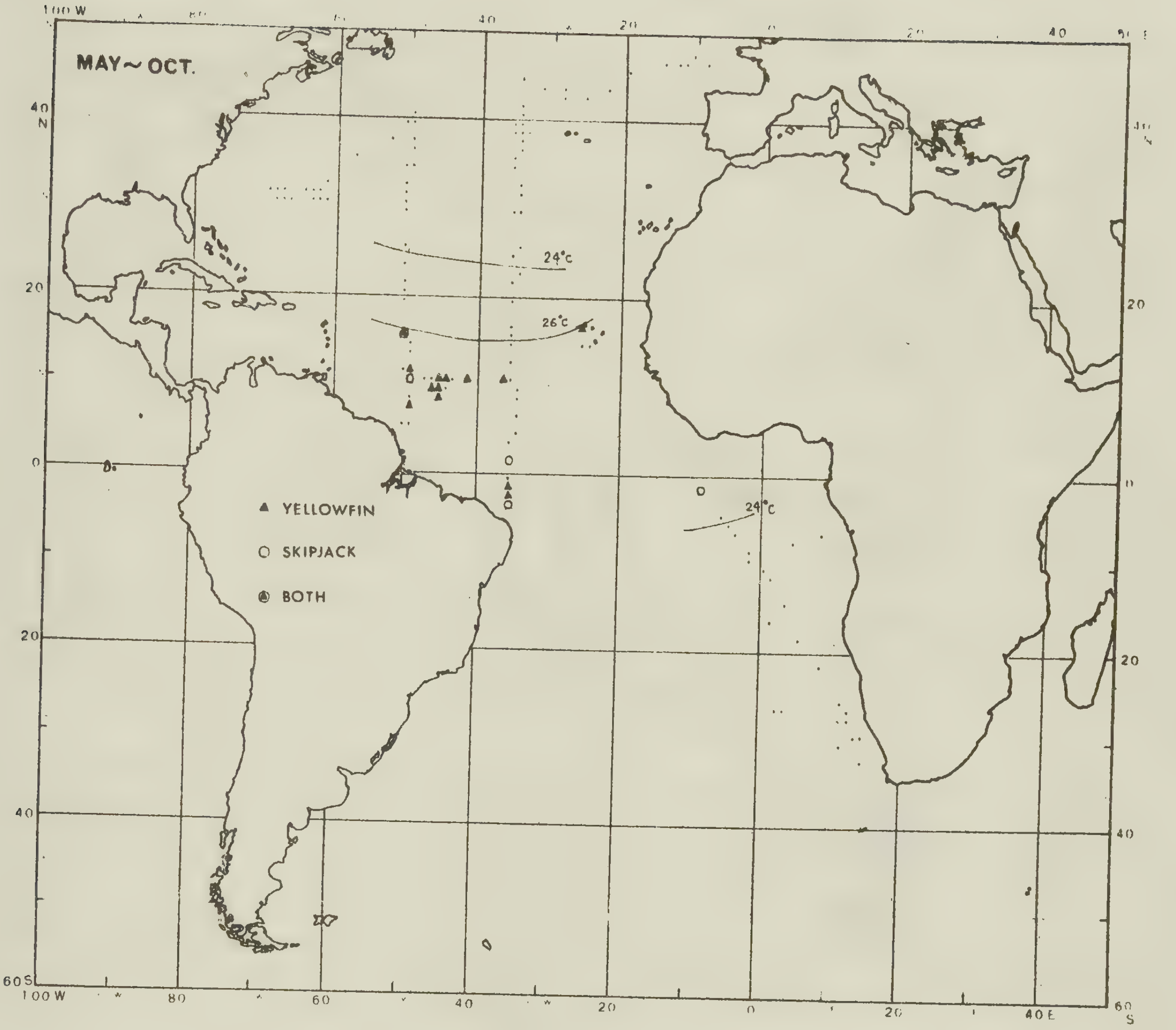
MAY ~ OCT.
▲ YELLOWFIN
○ SKIPJACK
◉ BOTH
24°C
26°C
24°C
100 W
80
60
40
20
0
20
40 E
40 N
20
0
20
40
60 S

Fig. 2 (b) Distributions of larvae of yellowfin and skipjack tuna. May–October. Small dots ... larvae absent

4.9

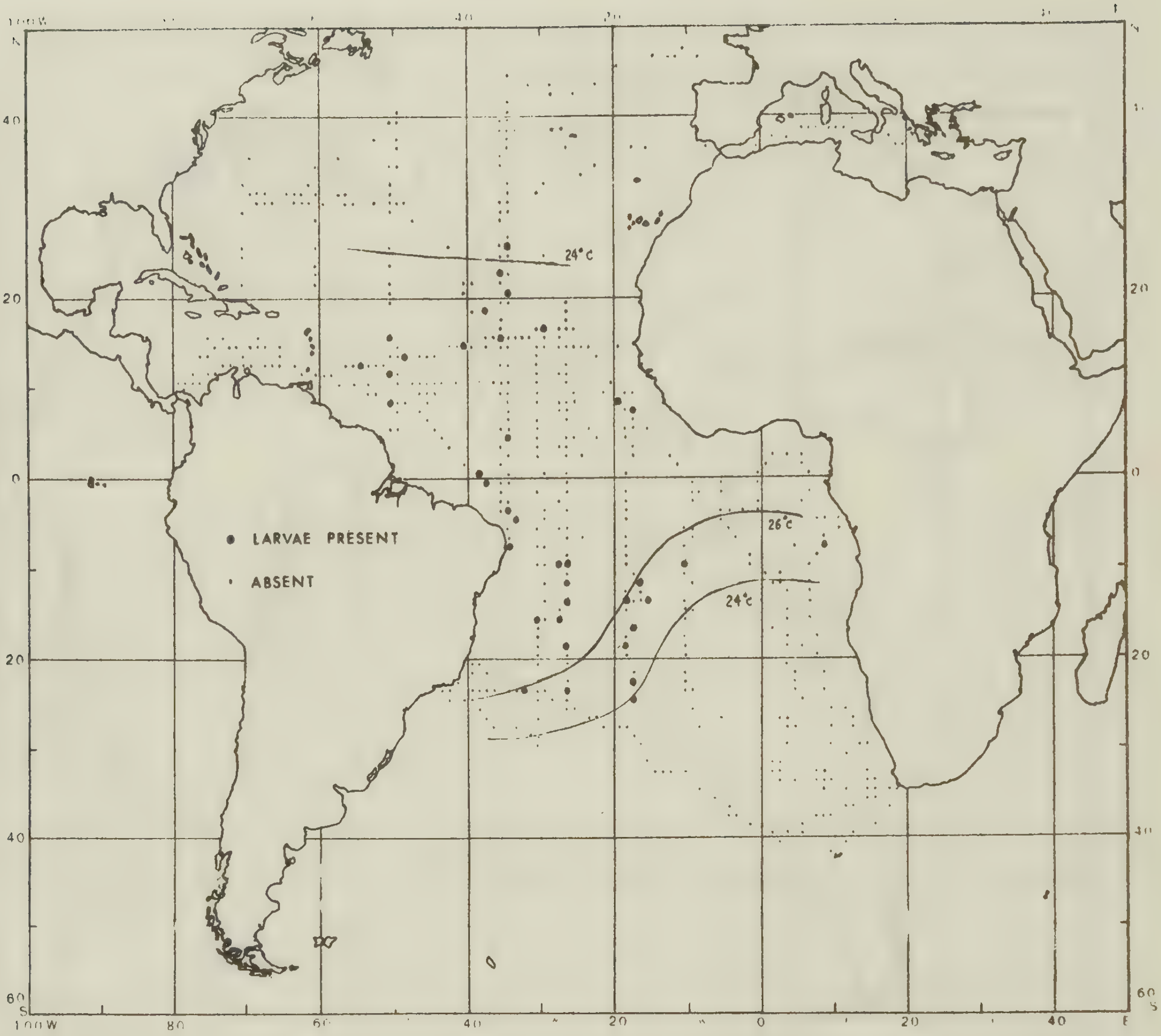
● LARVAE PRESENT
· ABSENT
24°C
26°C
24°C
100W
80
60
40
20
0
20
40
40
20
0
20
40
60
S
E

Fig. 3 Distributions of billfish larvae in the Atlantic Ocean. Large dots ●●●● larvae present, small dots .... larvae absent

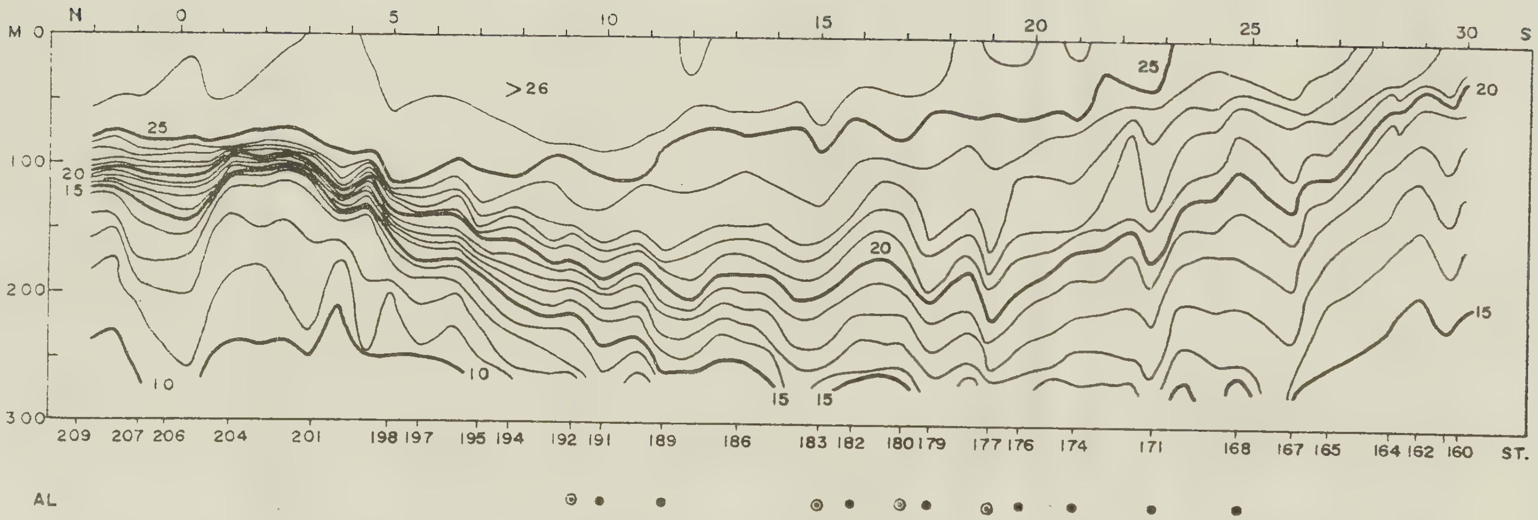

Fig. 4 Relationship between the occurrence of albacore larvae and the thermal structure (vertical temperature section) at time of survey. Along the 30°W meridian, December, 1965. Larval catch is shown on bottom: dots ... less than 9 larvae, circled dots, more than 10 larvae

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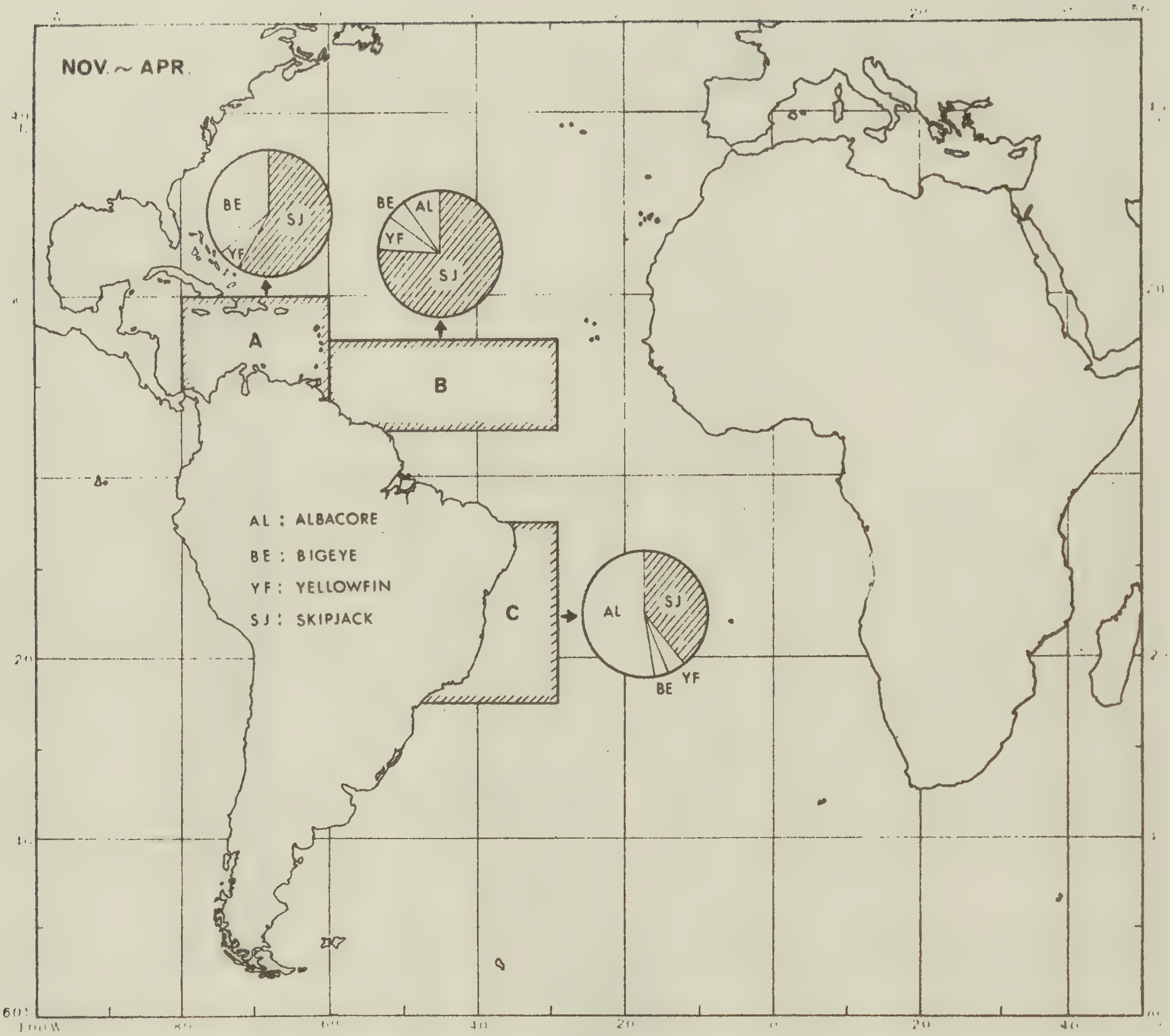
NOV. ~ APR.
A
B
C
BE
SJ
YF
AL
AL : ALBACORE
BE : BIGEYE
YF : YELLOWFIN
SJ : SKIPJACK
60S
100W
80
60
40
20
0
20
40

Fig. 5 Species composition of larval tuna by area

In the South Atlantic the spawning area of albacore during the southern summer is delineated approximately by the 10°S parallel (northern limit), Brazilian coast (western limit), the 25°S parallel (southern limit), and the 10°W meridian (eastern limit). We need more data in order to delineate the spawning area in the North Atlantic.

2.2 Bigeye tuna

Larvae of bigeye tuna (Thunnus obesus) have been collected mostly in the equatorial region from the Caribbean Sea to the Gulf of Guinea. In the western Atlantic the southernmost locality at which bigeye larvae have been taken is lat. 25°S off the coast of southern Brazil. The lower temperature limit of larval distribution appears to be 26°C, which is a little higher than for albacore larvae. The important spawning areas of bigeye tuna seem to differ from those of albacore.

2.3 Yellowfin tuna

The larval distribution of yellowfin tuna (Thunnus albacares) resembles that for bigeye tuna. The range of distribution, however, is likely to be wider for yellowfin tuna than for bigeye tuna.

2.4 Skipjack tuna

The distribution of larval skipjack tuna (Katsuwonus pelamis) is the most extended among the four species. The spawning areas of skipjack tuna appear to coincide with those of other tuna species.

3 SPECIES COMPOSITION OF TUNA LARVAE BY AREAS IN THE WESTERN ATLANTIC

The species composition of tuna larvae collected by larvae net tows is indicated in Figure 5 for the southern summer months (November through April) and for the areas in which we have much data.

Larvae of skipjack tuna are dominant in the Caribbean Sea (A - area) and in the adjacent eastern waters (B - area).

In the Caribbean Sea bigeye larvae and skipjack larvae seem to share the important part of the larval tuna population. Relative abundance of albacore larvae is considered to be largest among the tunas in the southwest Atlantic (C - area) during the southern summer months.

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THE CEPHALOPOD RESOURCES OF THE CARIBBEAN SEA AND ADJACENT REGIONS

by

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1 INTRODUCTION

Cephalopods, or octopus and squid, comprise one of the largest food resources in the sea. Occupying a niche near the top of the food pyramid, they represent a stock occupying large areas of the ocean and they occur in tremendous numbers. They are essentially clean in habits and environment, and are singularly free of inedible species. There are only two or three instances of illness caused by eating them; this may be compared with thousands of cases of seafood poisoning occurring annually as a result of eating scale fishes, crustaceans, and various shelled molluscs. There is less waste in preparing them for the table than in most other seafoods. The time required to reach maturity is remarkably short, in some cases no more than five months from emergence from the egg to sexual maturity and full growth. Their life span is likewise short, suggesting a crop with fast turnover and high utilization potentials.

Interest in the possibilities of squid and octopus fisheries remained low and at a local level until shortly after the second world war. Japan led the way with the high development of her fisheries for the common Japanese squid, Todarodes pacificus. In 1952, the Japanese production reached a high point of 646 000 metric tons and in home waters has levelled off at near 600 000 metric tons annually. In addition to home production, the Japanese have gone to foreign markets to increase the supply, actively buying squid from neighbouring countries and sending their own ships into many areas of the world ocean. Japanese squid fishing vessels now operate in the Gulf of Guinea off West Africa and Japanese fishing companies buy a large percentage of the catch from the Saharan Bank near the Canary Islands. Interest in opening new fields is increasing and other countries are beginning to develop their own fisheries. Spain and Portugal have long supplied much of the European market with both fresh and canned squid and this market is increasing. It is a high quality product and demands a good price. North America imports an increasing amount of canned squid and octopus, partly from Japan but mainly from Spain and Portugal.

The major consumer market for cephalopods lies in the Orient and among Mediterranean peoples or people of Mediterranean extraction. North and Central Europeans and the English speaking people of North America are in the main unacquainted with these animals as a possible major food. This is entirely due to the usual prejudices against eating unfamiliar foods and has not been ameliorated by recent writers. Once a person has been introduced to octopus and squid, it usually becomes an accepted and relished dish. Included in the dislike of North Europeans and Americans is the conception that octopus and squid are tough. This is a popular misconception due largely to attempts to prepare squid without recourse to proper methods and to continual repetition of this fallacy by both popular and fisheries writers.

The major fisheries for squid by English speaking peoples is in Newfoundland, where most of the take is sold for bait to the Grand Banks handline cod fishermen. Even in this fishery an attempt is now being made to utilize part of the catch for food. The fishery amounts to about 11 000 metric tons annually. It is limited not by the availability of squid but by freezer capabilities.

The cephalopod potential of the North Atlantic is very great. A dramatic picture of the growth of this fishery was presented by Dr. García Cabrera, Director of the Institute of Oceanography at Santa Cruz de Tenerife at the Canary Islands Symposium held this year. Before 1962 the cephalopod catch on the Saharan Banks was incidental to the scale fishery and of little importance. In 1963 the catch of octopus, cuttlefish, and squid began a dramatic upswing and in 1967 amounted to over 600 000 metric tons. It is predicted that the 1968 catch will exceed 800 000 metric tons. The value to the fishermen runs to US$150 per ton for squid to US$300 per ton for octopus. This may be compared with the present US$20-30 per ton paid for squid to the Newfoundland fishermen where it is used for bait.

Interest in the cephalopod fisheries continues to increase in an attempt to meet the market demand. In the West Indies and adjacent areas no large fisheries exist. Since this group comprises a major largely unexploited food resource it represents a great potential. It is for this purpose that I propose to give a survey of the present fishery in the tropical Western Atlantic, the local market and demand, and the possibilities for the development of the resource.

In preparing this paper I was fully aware of the paucity of our information on the occurrence of cephalopods in the area covered and of the unreliability of the few available statistics. The general information concerning the exploitable species and their distribution is based upon my own data obtained over a period of some fifteen years of research and exploration of the region. The information on the fisheries, landing, gear, areas of concentration and other information were derived from replies to a questionnaire distributed this autumn and I wish to take this opportunity to thank all of the various biologists, fisheries specialists, and administrators who have furnished me with so much pertinent data. The only country from which data were not obtained was Cuba, due almost certainly to the involved mail procedures between our two countries.

The following information was requested on the questionnaire:

1. Tons of octopus landed in 1966 and/or 1967
2. Tons of squid landed in 1966 and/or 1967
3. Value of the total catch (in local currency or US$)
4. Is catch sold fresh, frozen, dried or canned?
5. Is there a special fishery for octopus and squid or is the catch incidental to other fisheries? What type of gear is used?
6. Where are the main areas from which these animals are taken?
7. What amount of canned octopus and squid are imported from Spain or Portugal? Value of import in local currency or US$
8. What is the price per kilogramme paid to the fisherman? Paid by the housewife?
9. Do you believe there is sufficient demand for octopus and squid in your country to develop a large fishery if octopus and squid are present in commercial quantities?

The results of this questionnaire will be summarized later.

In 1959 I gave a paper on the potentials for octopus and squid fisheries in the West Indies (Voss, 1960) at the Twelfth Annual Session of the Gulf and Caribbean Fisheries Institute in Nassau, Bahamas. It is interesting to note that there has been little increase in the cephalopod fisheries during the intervening nine years.

2 COMMERCIAL SPECIES OF CEPHALOPODS OF THE TROPICAL WESTERN ATLANTIC

The tropical Western Atlantic is rich in species of cephalopods but only six species of squid and four species of octopus are considered of potential commercial value. These are selected because of their size, availability and present utilization in at least some of the areas covered by this report.

2.1 Squid

The loliginid squids are littoral animals mainly concentrated over the continental shelf in comparatively shoal water. They school together during most, or at least part, of the year and are amenable to capture with conventional fishing gear. They are also members of a group prepared for food in the Mediterranean and in the Orient. There is a present world market for them. Four species occur in our region.

Loligo pealei (Lesueur, 1821). This is the so-called "common"squid of eastern North America and is fished along the northeastern coast of the United States. It occurs in most areas of the continental shelf from south Florida through the Gulf of Mexico and has been reported from various scattered areas in the Caribbean. It attains a total length of about 0.5 m and is excellent eating (Figure 1).

Doryteuthis plei (Blainville, 1823). This is the so-called arrow squid of tropical waters to which it is confined. It has a wide distribution in the tropical Western Atlantic although records are scanty in some areas but this is not considered an indication of its absence but rather of poor records. This is a large squid attaining a length of about 0.7 m, but is slender and not as heavy as L. pealei. It is usually confused with the latter. It is of good quality (Figure 2).

Lolliguncula brevis (Blainville, 1823). This is the "thumb-stall" squid of the Atlantic coast of the United States where it occurs from Delaware southward. It is widely distributed along the continental coastline but it is infrequent or lacking in the Antilles as it seems to be associated with areas of slightly low salinities; it occurs in salinities as low as 17°/oo. This is a short bodied, heavy squid, very meaty and ideal for canning (Figure 3).

Sepioteuthis sepioidea (Blainville, 1832). This species resembles, in overall aspect, the cuttlefish of the old world, and is responsible for most of the erroneous records of cuttlefish in the literature of the Americas. It is a strictly tropical species occurring in Bermuda, and south Florida from Miami to the Florida Keys. It is mainly an island species according to our present knowledge and is distributed from the Bahamas and Cuba southward to Trinidad. It has only been reported on the mainland from northern Yucatan, the Honduras-Nicaragua border and Venezuela and Curaçao. This is a medium-sized squid, heavy, meaty, and of good quality (Figure 4).

Two other species of commercial importance belong to the family Ommastrephidae, to which belong the main commercial squid of Japan. These are in general high seas squid but one, at least, is known to come into shallow water in northern areas.

Illex illecebrosus illecebrosus (Lesueur, 1821). This species is widely distributed around the Atlantic Ocean in at least three forms or subspecies. The Caribbean form is considered to be the same as the "common squid" of Newfoundland. In Newfoundland it occurs in waters of about 15-25 m on the squid fishing grounds but in the warmer waters of the tropical Western Atlantic it lives at depths of about 180-450 m, obviously descending in depth to colder waters. We know little about its habits in the tropics but it was seen by Idyll and Robins in considerable numbers at 650 m off Miami in a dive in the Aluminaut and it shows up in commercial trawls in fair quantities. Food quality is excellent (Figure 5).

Ommastrephes pteropus (Steenstrup, 1855). The "orange back" squid "lomo anaranjado" gets its name from the large orange-coloured light organ on its back which glows plainly even from a distance. This is strictly a high seas squid not encountered over the continental shelf but easily brought to a boat's side at night with an electric light. It reaches a large size, is very heavy and meaty, and the supply seems nearly inexhaustible (Figure 6).

2.2 Octopods

There are about eight common octopus in the tropical Western Atlantic. However, four of these are small species and probably are not worthwhile considering. The remaining four species reach a considerable size and at least three of them already form the basis for fisheries in some areas of the world.

Octopus vulgaris (Cuvier, 1797). The common octopus (pulpo común) is world wide in distribution. It lives on the continental shelf from the outer edge to the intertidal. It obtains a large size and is a preferred food species in most markets of the world. It lives in holes on hard bottom or in old conch shells or other similar formations. It is distributed throughout the temperate and tropical seas of the world (Figure 7).

Octopus briareus (Robson, 1929). This species is very common throughout most of the region, living in shallow water. It is known as "fabiana" in Cuba and is a commercial species in that country. It attains a large size and locally may be very common (Figure 8).

Octopus macropus (Risso, 1826). The "grass scuttle", as this species is called in Bermuda, is world wide in distribution. It attains a large size and is common in the fish markets of the Orient. It is rather uncommon in south Florida waters but is common in the Bahamas. Little is known of its distribution in the West Indies (Figure 9).

Octopus maya (Voss and Solís, 1966). This large ocellated species is the source of the large fishery in the state of Campeche, Mexico. The fisheries and the biology of the species have been reported upon in full by Solís Ramirez (1967). Its full distribution in the Caribbean Sea and Gulf of Mexico is yet to be determined (Figure 10).

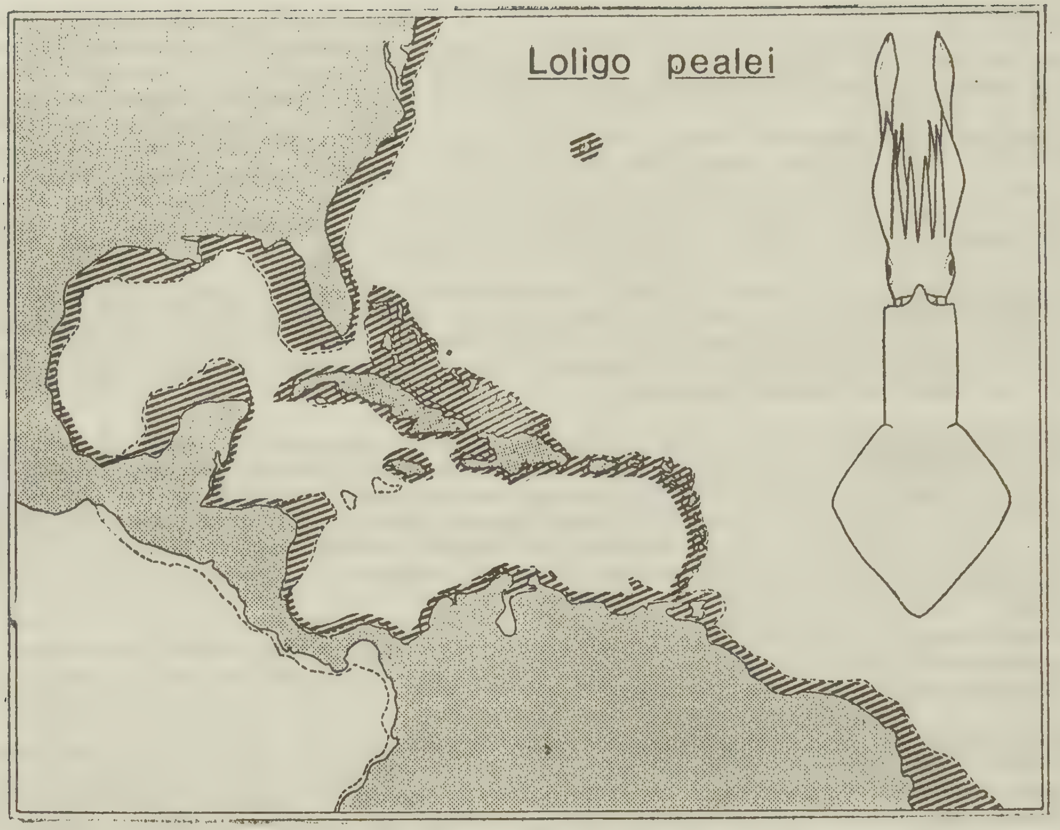
Loligo pealei

Fig. 1 Geographical distribution of Loligo pealei (Squid figure after La Roe, MS)

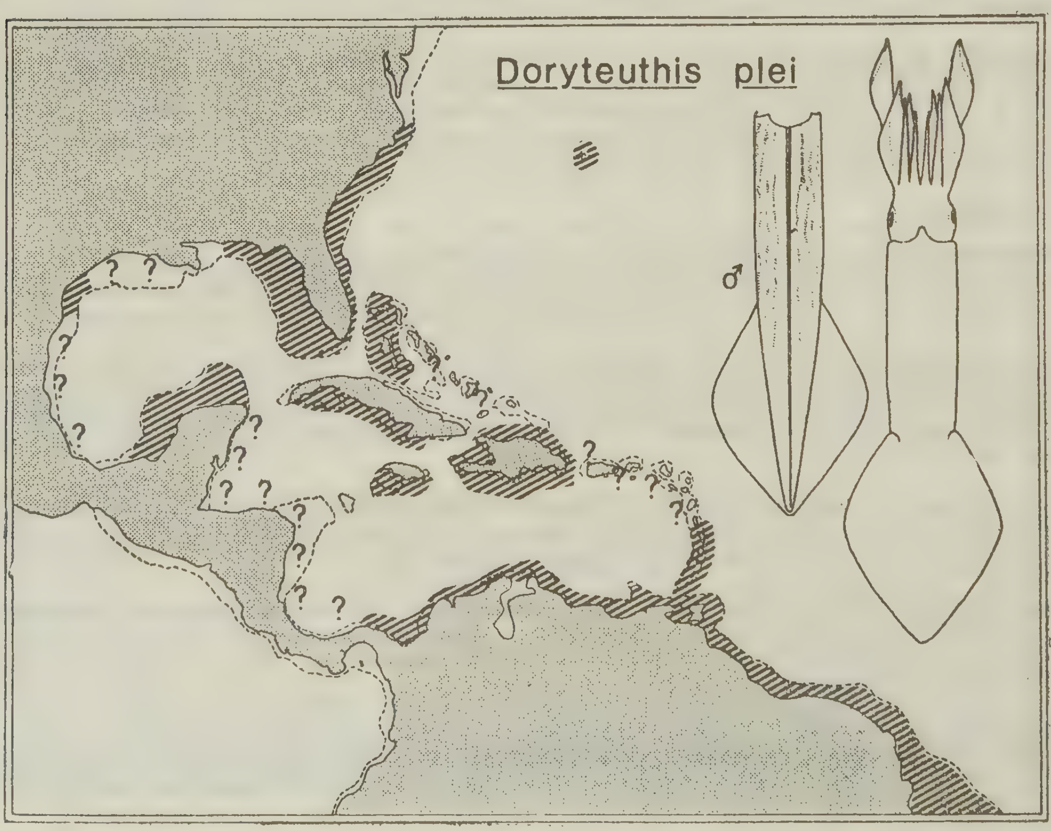
Doryteuthis plei
♂
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Fig. 2 Geographical distribution of Doryteuthis plei (Squid figure after La Roe, MS)

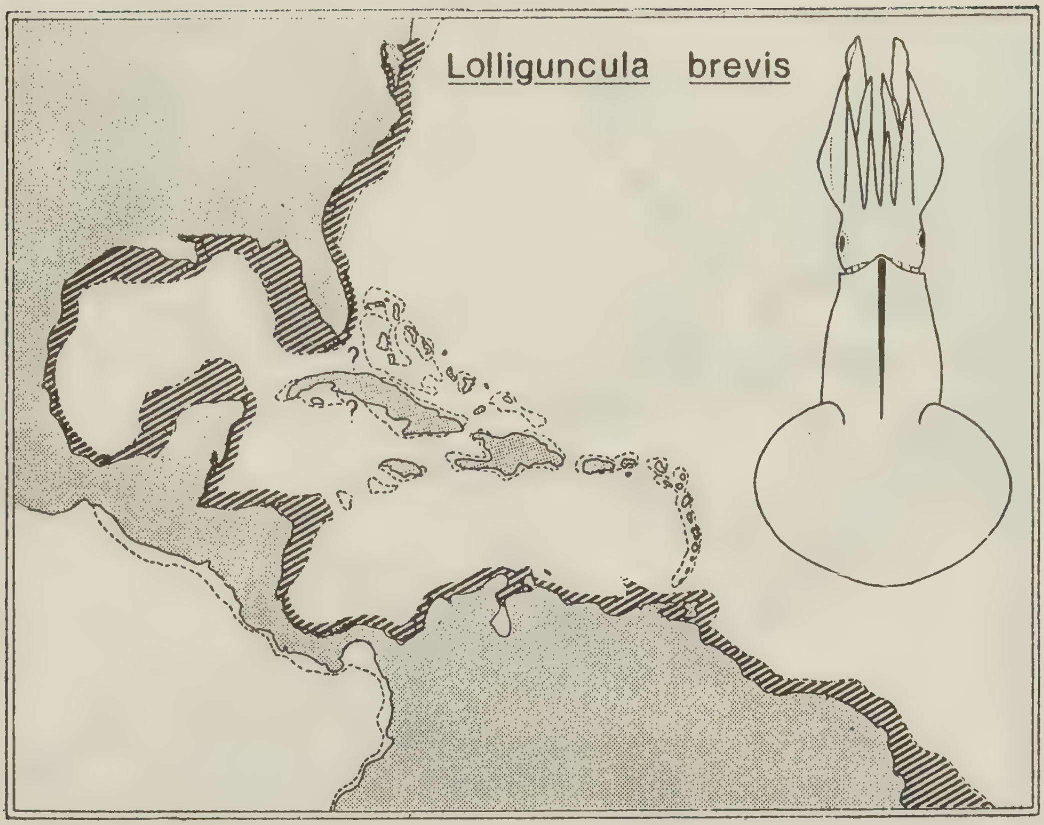
Lolliguncula brevis
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Fig. 3 Geographical distribution of Lolliguncula brevis (Squid figure after LaRoe, MS)

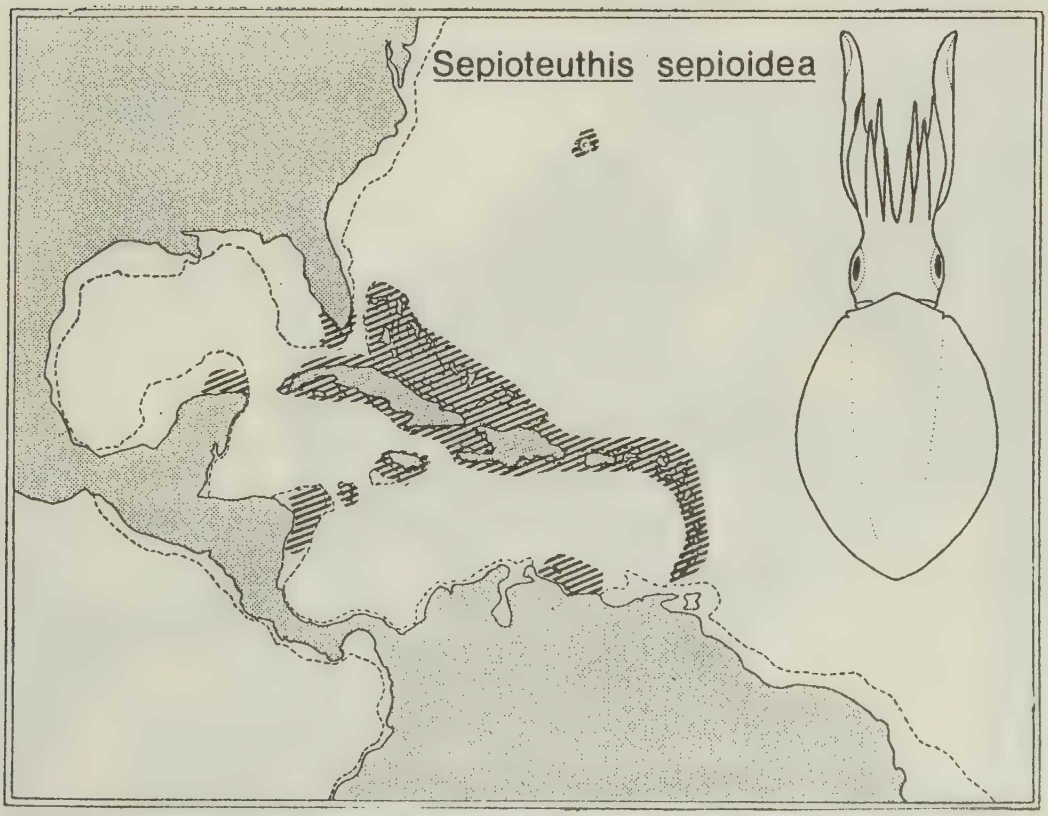
Sepioteuthis sepioidea

Fig. 4 Geographical distribution of Sepioteuthis sepioidea (Squid figure after La Roe, MS)

4.35

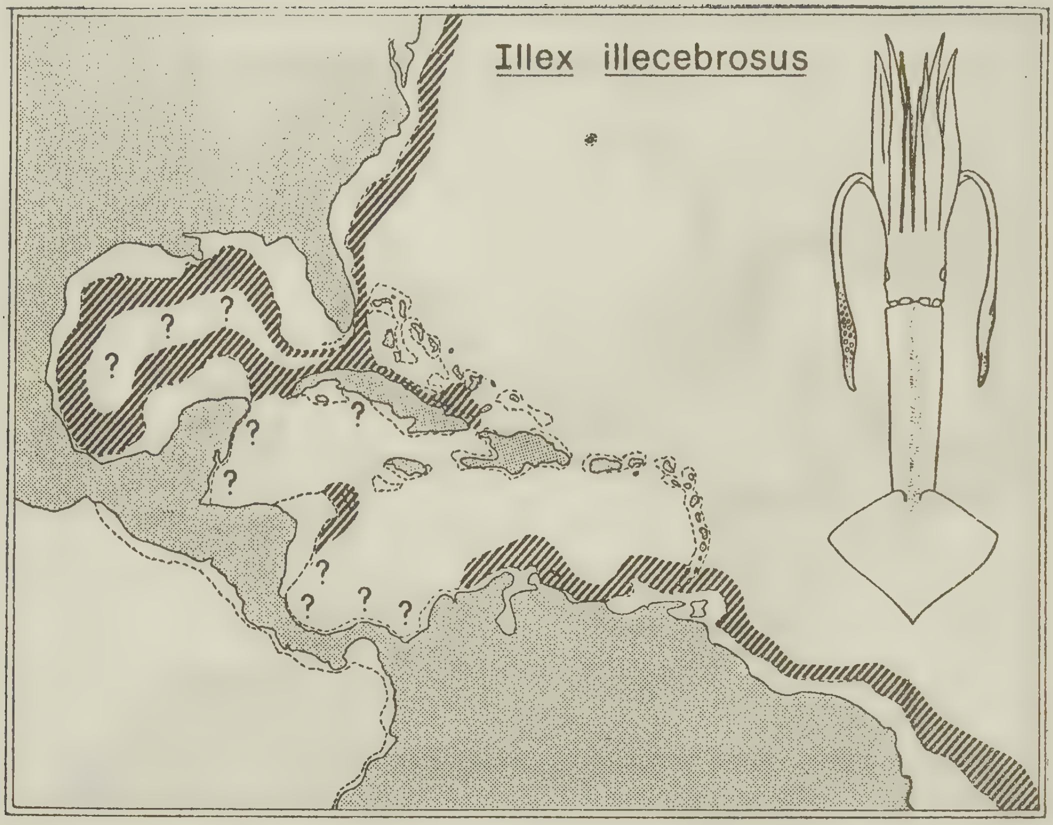
Illex illecebrosus
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Fig. 5 Geographical distribution of *Illex illecebrosus* (Squid figure after La Roe, MS)

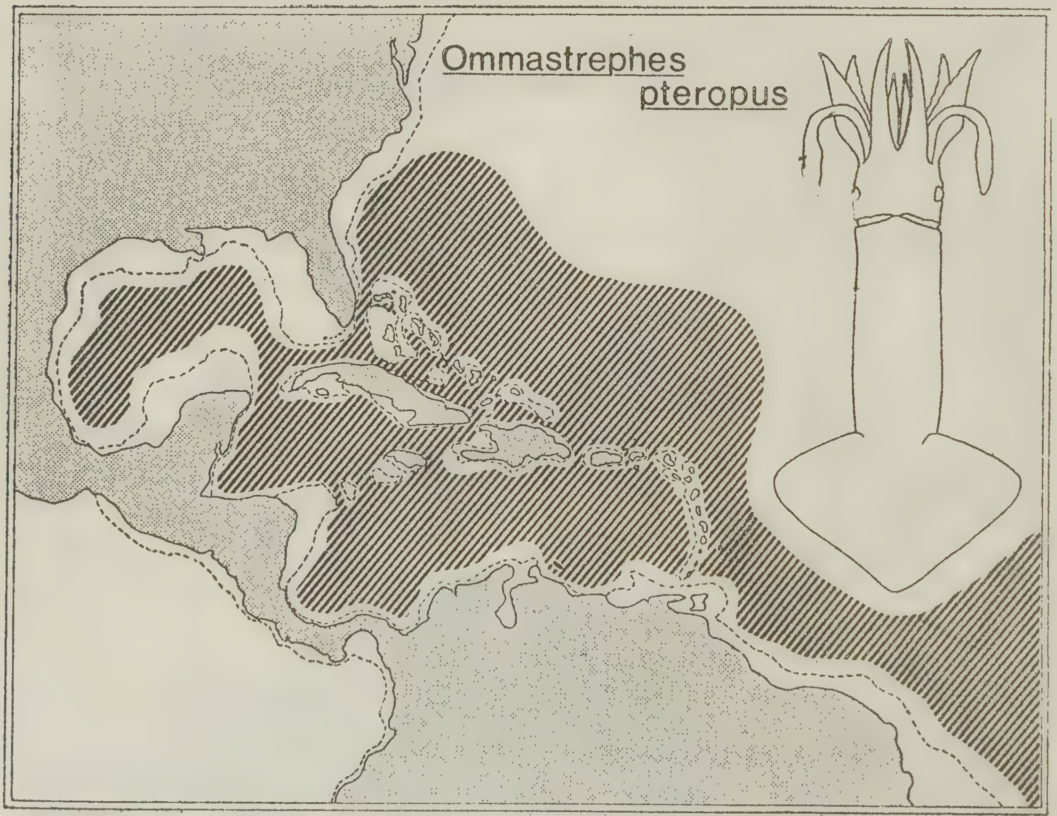
Ommastrephes pteropus

Fig. 6 Geographical distribution of *Ommastrephes pteropus* (Squid figure after Roper, 1963)

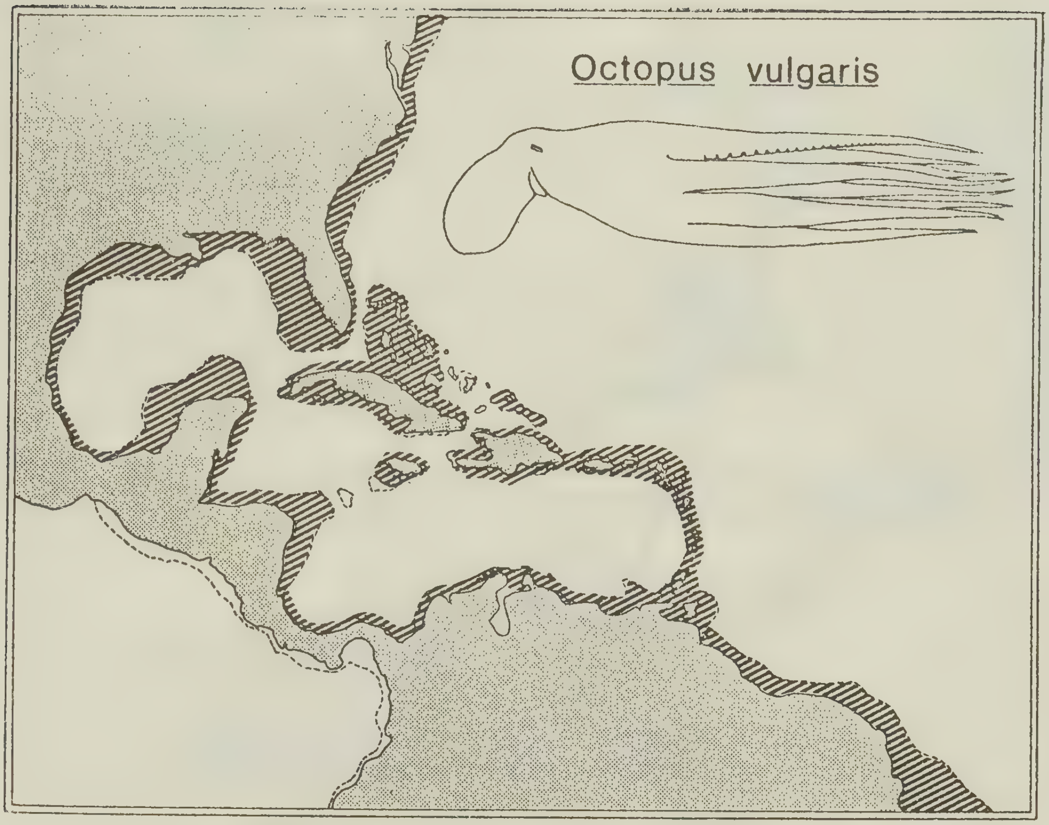
Octopus vulgaris

Fig. 7 Geographical distribution of Octopus vulgaris

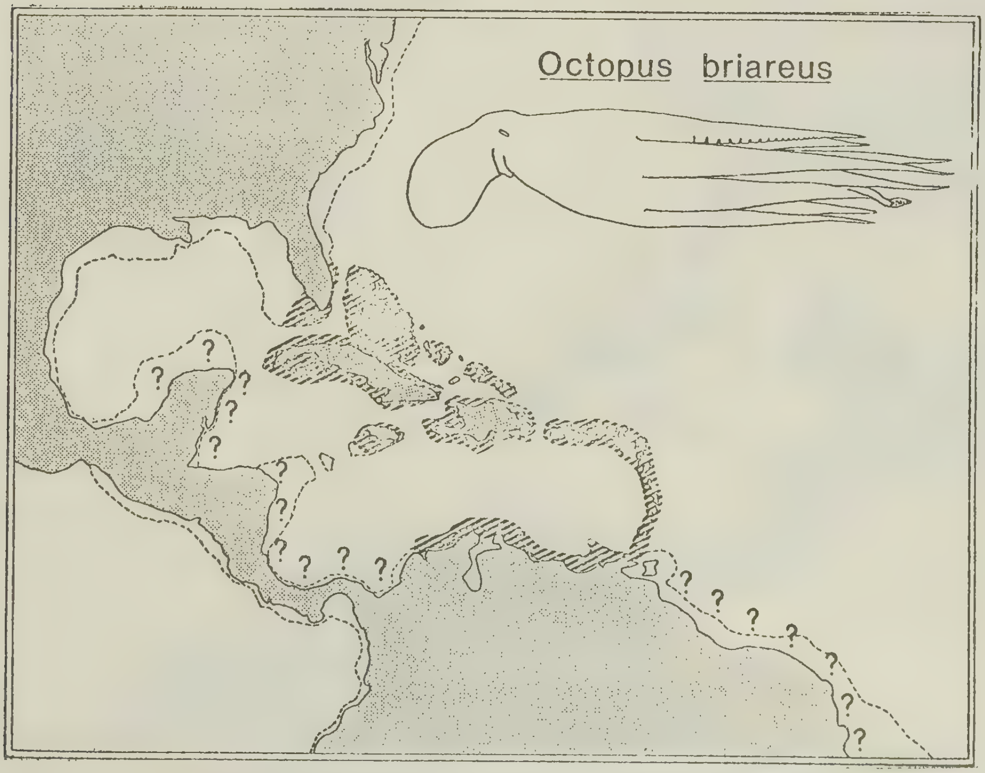
Octopus briareus
?

Fig. 8 Geographical distribution of Octopus briareus

4.35

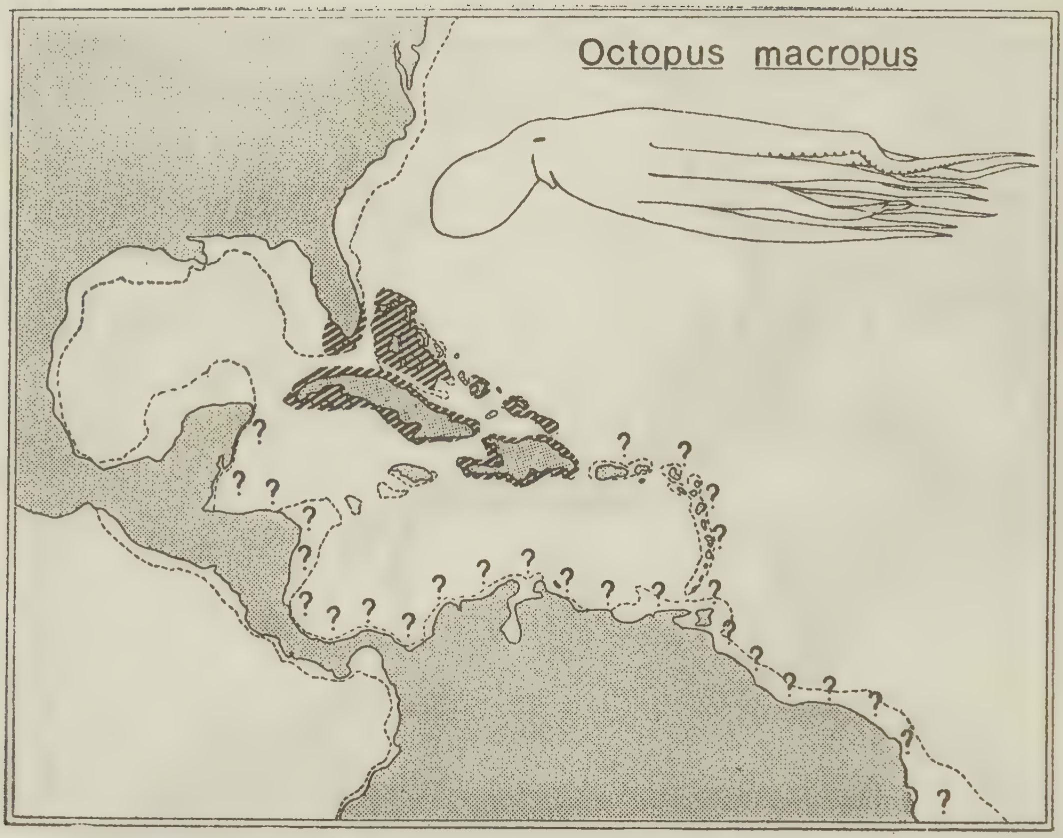
Octopus macropus
?

Fig. 9 Geographical distribution of Octopus macropus

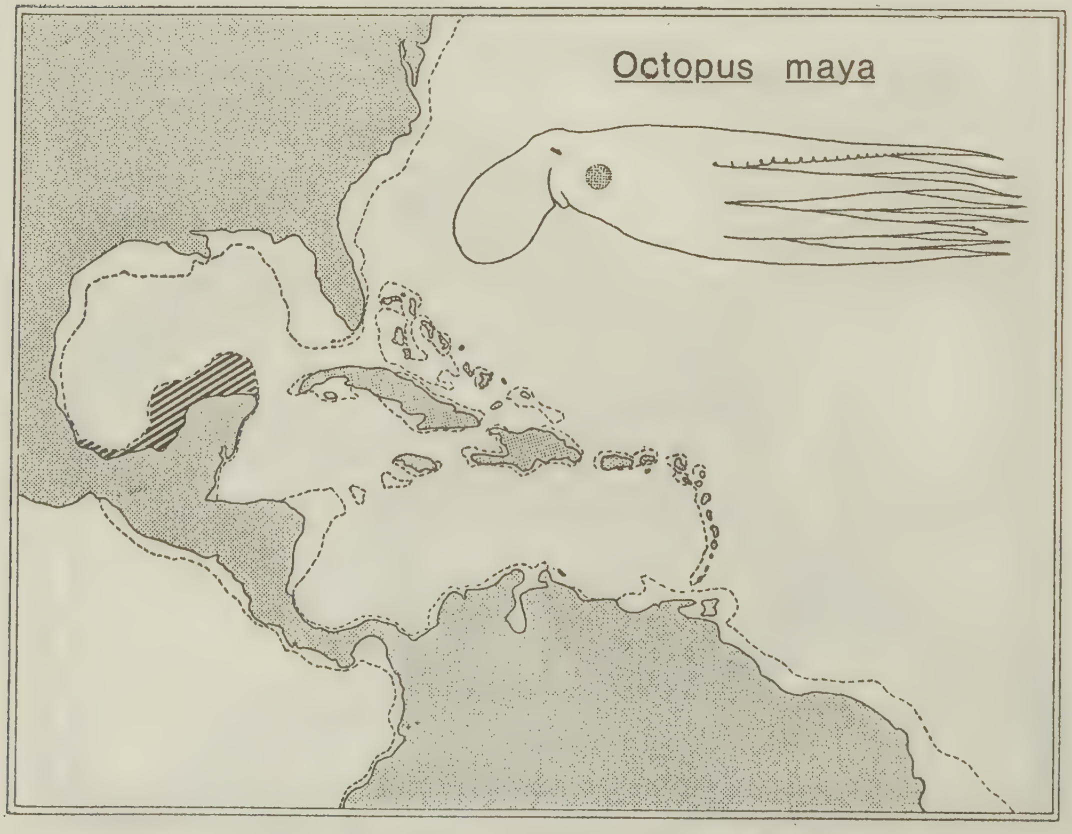
Octopus maya

Fig. 10 Geographical distribution of Octopus maya

3 PRESENT STATE OF THE FISHERIES

Surprisingly, the cephalopod fisheries in the tropical Western Atlantic are very undeveloped and in fact in most of the countries are non-existent. While this might be expected in the English speaking countries, it is a matter of some surprise that in the countries of Spanish and French origin only a few have even a local consumption and many do not eat them at all. In considering this matter I have reached the conclusion, rightly or wrongly, that the taste for octopus and squid is present only in those areas having the greatest continuing strong ties with France and Spain and that in other areas knowledge of these animals has been lost.

Information about the fisheries is particularly difficult to obtain because in many areas octopus and squid are taken locally in small quantities by the shore dwellers or in small quantities incidental to other fisheries and specimens never reach the local market where they could be seen by the local fisheries officer. In some areas octopus, for instance, are taken locally in considerable and appreciable quantities yet because they are not "landed" they are not listed in the yearly fisheries statistics. Fisheries of this kind are particularly difficult to judge. For instance we know that the octopus fishery in China and Japan is very large, amounting to thousands of tons annually but practically none of the catch is reported upon in the yearbooks.

In order to survey the cephalopod fisheries of the Caribbean and adjacent areas in a meaningful manner, they have been divided into two categories, octopus and squid. These categories are then considered through the islands from Bermuda to Trinidad, Mexico and Central America, and northern South America (Figure 11).

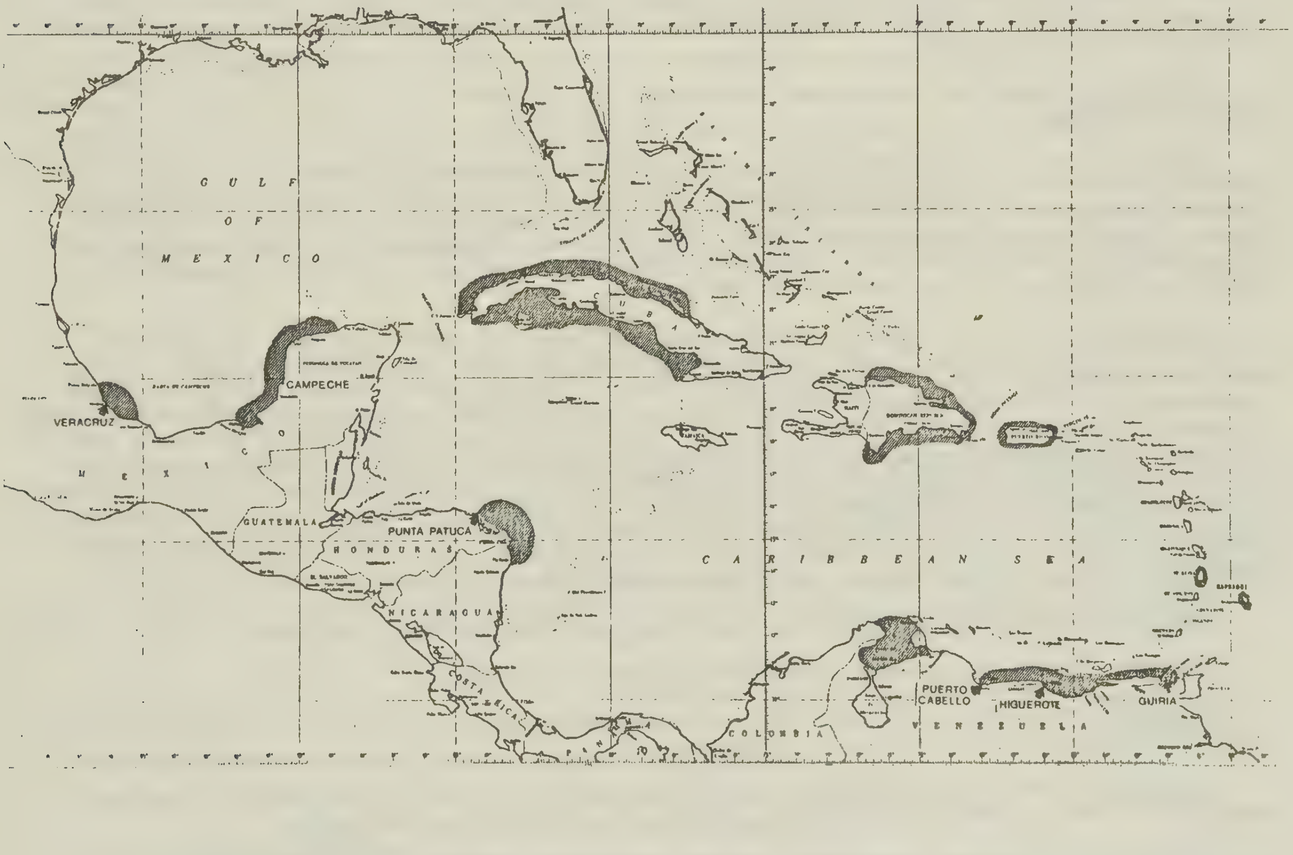

Fig. 11 Locations of squid and octopus fisheries in the Caribbean Sea and adjacent areas

3.1 Octopus

3.1.1 Island Fisheries

Bermuda: both the "grass scuttle" O. macropus and the "rock scuttle" O. vulgaris occur in the waters around Bermuda. There is no fishery although occasionally a few are taken locally. They are seldom eaten but are often used for bait.

Cuba: All four species of commercial octopus probably occur in Cuban waters. There is a good demand for fresh octopus both from the housewife and from the seafood markets. The octopus are caught either in fish traps or hooked out of their hiding places by a hook on the end of a short pole. This is thrust into the lair, given a quick turn and pulled out, usually with an octopus. The octopus are located visually either by using a waterglass or by smoothing the sea surface with a few drops of oil. The octopus is killed by "turning the cap" or inverting the mantle by placing the fingers in the opening under the head and wrenching the mantle inside out, ripping loose the adductor muscles. This same method is universal wherever octopus are fished. In 1959, the latest figures available, fresh octopus brought US$.80/kg in the market. The entire coastline of Cuba produces octopus although the principal areas fished are in the vicinity of the larger cities. No statistics are available on the kilogrammes produced.

Bahamas: Although octopus or "sea cats" are common in the Bahamas there is no fishery and most of the fishermen fear them. A few are used for bait.

Hispaniola: Unfortunately, no information is available from Haiti. In the Dominican Republic there is a considerable fishery for octopus. In 1967 the octopus catch amounted to 11 758 kg with a value of US$8 818. The catch is sold fresh shortly after the time of capture. The whole coast of the Republic is fished, usually utilizing some kind of fish trap or hand gear. The fisherman received about US$.75/kg for his catch.

Turks and Caicos: No fisheries and the natives fear "cuttles" which are only eaten by an occasional Jamaican fisherman.

Jamaica: Drew (1919) reported that in 1912 there was a considerable fishery for octopus or "sea cats" at Montego Bay. However, both Stevens and Goreau of the University College of the West Indies (personal communications, 1959) state that they have never seen an octopus or squid in a commercial catch. Munro (personal communication, 1968) states that the octopus catch is insignificant and that the animals are used only for bait. Octopus are captured by dangling an old rope into crevices in the back-reef area and off old jetties and wharves.

Puerto Rico: The only figures and information available from Erdman (personal communication, 1959). The octopus taken are mainly O. vulgaris and they are caught in considerable numbers although there are no valid statistics for the island as a whole. The main period of the fishery is November and December and the period October through March is the season when the females come into shallow water to spawn. According to Erdman, by July the small octopus weigh about .15-.25 kg but by October over 0.5 kg, and by February 1 kg or better. The animals are caught by thrusting a crawfish grain or two-tined spear into the hole, giving it a twist, and usually an octopus is brought out. In larger holes on the north coast a three-foot iron rod is used with a barbless hook at the end. At La Parguera there are about six part-time octopus fishermen who each make about US$1 000 per year, or half the average income of a Puerto Rican fisherman. Their catch averages about 30 kg per day but a good fisherman may get as much as 50 kg. In 1959 they brought US$.50/kg fresh.

Virgin Islands: Caught only for bait and infrequently as the natives fear them.

Antigua: Incidental and small; no information could be furnished.

Monserrat: No octopus are caught and they are not utilized locally. Large ones are seen in the rocks all around the coast but there is no demand.

Guadeloupe: Octopus occur around Guadeloupe but there is no fishery. The catch is local and occasional. Small octopus bring US$1.50/kg, however, so a demand of a sort exists.

Dominica: The catch is negligible. Octopus are taken in fish traps and by cat-hooks but in insignificant quantities. They are taken mainly from the north and west (windward coasts) in lagoons and reefs. When caught they bring between US$.60 to US$1/kg.

St. Lucia: The catch is negligible amounting to about 5 000 kg per year. Its value is about US$500. There is no special fishery and the catch is dependent upon other fishing operations. Most come from the west coast of the island and most are probably used for bait.

St. Vincent: None.

Grenada: Octopus occur in its waters but they are not fished.

Barbados: There is a substantial personal use for "sea cats." Rathjen (personal communication) reports that in spring low tides hundreds of young men go out for octopus searching for them with spears on exposed coral ridges.

Netherlands Antilles: The fishery over the whole area is negligible but when specimens are caught in traps or on handlines, they are eaten.

3.1.2 Mexico and Central America

Mexico: There is an established fishery both in Veracruz and Campeche for the octopus, O. maya. In 1967 the catch for both ports amounted to 1 617 000 kg with a value of about US$300 000. The catch is shipped to Mexico City and elsewhere. About 50-60 percent is frozen, 20 percent fresh and 20 percent canned. The main fishery season is October and November. Most of the catch is taken by handline with crabs for bait or with artificial crabs but in Veracruz the small fishery is carried out with octopus hooks at the end of poles. The fisherman receives about US$.10 per kg for which the housewife pays about US$.40 per kg. Recently attempts have been made to sell canned octopus in the United States but it has not been able to compete with the Portuguese and Spanish product. The area of fishery is in the State of Campeche around Campeche, Champotón and Ceibaplaya which in the period 1965-67 produced 1 315.3 metric tons. The Veracruz fishery is immediately around the port.

British Honduras: No fishery exists and even when specimens are caught incidentally, they are thrown overboard.

Guatemala: There is no fishery for octopus in this country at the present time. However, it is hoped that a fishery can be started if it is possible.

Honduras: None.

Nicaragua: No octopus are caught or sold in this country and it is doubtful if the populace is aware that they are edible.

Costa Rica: None.

Panama: None.

3.1.3 South America

Colombia: The main fisheries of Colombia are located in the Pacific and little fishing is undertaken in the Caribbean. A few octopus occur in the market from time to time but no figures are available as to quantities or prices. They are not eaten singly but used in Paella Valenciana in combination with other mariscos.

Venezuela: Venezuela produces about 9 246 kg of octopus mainly from the central zone (Higuerote to Puerto Cabello) and the eastern zone (Higuerote to Güiria). The value at the wharf is US$1.85 per kg for which the housewife pays about 2.5 times increase. The catch is sold fresh and canned, mainly to immigrants lately from Spain.

Guyana: None.

French Guiana: None.

3.2 Squid

3.2.1 Island Fisheries

Bermuda: None.

4.35

Cuba: The main catch of cephalopods in Cuba is squid accounting for most of the total production in 1958 of about 10 000 kg. Undoubtedly this is much greater today as the yearbook gives figures of about 200 000 kg. The catch is incidental to the shrimp catch but some are taken by cast nets (atarraya) or jigs (poteras). Squid are captured all around the island.

Bahamas: None.

Hispaniola: No information is available on Haiti. The Dominican Republic produced 26 265 kg of squid in 1967 valued at about US$40 000. The catch is sold fresh immediately after capture. Much of the fisheries is carried out with dip-nets and lights. The price to the fishermen is about US$1.50 per kilogramme.

Jamaica: The fishery is inconsequential, small numbers of squid being caught in beach seines. They are not eaten but are used as bait.

Puerto Rico: There is no fishery and only occasional catches are made.

Virgin Islands: None.

Antigua: None.

Montserrat: Squid are infrequently caught and are either thrown away or used as bait.

Guadeloupe: There is no fishery and incidental squid are used for bait.

Dominica: A few squid are taken using beach seines or dip nets with a 300-candle power light at night. Squid, when caught, bring a price of US$.60 to US$1 per kilogramme.

St. Lucia: The catch is negligible, amounting to a value of about US$500 per year. Most of the catch is used for bait.

St. Vincent: There is no fishery.

Grenada: The catch is negligible and is mainly used for bait for demersal fishes, although a few are eaten.

Trinidad and Tobago: A few squid are caught in beach seines and used for bait.

Barbados: Negligible.

Netherlands Antilles: No fishery.

3.2.2 Mexico and Central America

Mexico: The squid catch in Mexico is very negligible and no official statistics are available. Solís informs me that the 1967 catch in Campeche only amounted to about 13 270 kg. They are incidental as "trash" or "pacotillo" except in a few areas. Most of the catch comes from the Pacific but there is a small fishery at Progreso, Yucatán, based upon *Doryteuthis plei*. The fishery is carried out from cayucos with sails or outboard motors, using a Coleman lantern and lines baited with half-beaks (*Hemiramphus*). When squid collect, they are dip-netted. They are sold at the beach for from US$.50 to US$.80 apiece to local purchasers. The fishery in 1967 amounted to US$265.

British Honduras: Any squid caught incidentally are thrown away.

Guatemala: There is a small fishery on the Pacific coast amounting to only some US$900 in 1967 but there is no fishery in the Caribbean.

Honduras: The squid fishery is incidental to the shrimp fishery. It was estimated by Loesch (personal communication) that the annual catch runs about 67 000 kg with a value of about US$29 000. The price paid to the fishermen is US$.44 per kg. The main fishery area is from Punta Patuca to the Nicaraguan border in depths down to about 40 metres. The catch is frozen and exported to the U.S.A.

Nicaragua: There is only a small catch from the shrimp boats. The fish house does not process the squid but gives them to the boat captains who take them home to eat.

Costa Rica: None.

3.2.3 South America

Colombia: There is no squid fishery in the Caribbean Sea area.

Venezuela: This country produced about 663 277 kg of squid in 1967 with a value of nearly US$300 000. Most of the squid came from the Gulf of Venezuela from the shrimp boats. The catch is mainly sold in the Caracas - Valencia area and is sold fresh or canned. The canned squid is produced in the main canneries at Cumaná.

Guyana: None.

French Guiana: The squid landed in French Guiàna are taken by shrimp trawlers north of Belem. It was estimated that about 50 000 kg of squid are caught annually but only about 4 000 kg are brought in; the rest are thrown overboard with the trash fish. No prices are available.

Based on these somewhat unreliable figures, the total cephalopod catch recorded for the Caribbean and adjacent areas in 1967 was approximately 2 552 574 kg or 2 552 metric tons, valued at about US$500 000, an insignificant figure considering the total fisheries yield of the area. On the other hand, for those countries where figures are available, 345 748 kg of canned cephalopods, primarily squid, are imported annually at a cost of about US$258 917. Both figures should be considered as a minimum.

A survey of the data given above shows that even where no true fishery exists, the price paid for octopus and squid is relatively high (US$.20 to US$1.80 per kg) and upsets the often given statement that there is no demand.

4 FISHING METHODS

4.1 Octopus

The fishing methods for octopuses have been alluded to above. Essentially, these methods can be placed in three categories: hooking and spearing, baits and lures, and traps.

Hooking and spearing: This method is the common fishery practice except in Jamaica and Campeche. It is an individual fisherman technique on a hunter basis: the fisherman searches for the individual octopus hole. When a lair is discovered, the fisherman thrusts a short pole, bearing a stout hook, into the hole and if an octopus is present, it is caught and hauled out. In some areas crawfish grains are used instead of the cat-hook. Since rippling of the water obscures the view, a water glass is sometimes employed but more often the water is smoothed by sprinkling a few drops of cooking or fish oil on the surface.

In turtle grass areas and even some reef tracts some species of octopus may come out into very shallow water to sun themselves, or fish, lying motionless for hours at a time. They can easily be taken by spearing as is common in Barbados.

It is doubtful if this hunter method of octopus fishing can ever support a real fishery and it is usually pursued on a local, individual fishing basis.

Baits and lures: In Campeche, most of the octopus fishery is pursued by drift fishing (al garete). In this (Solís, 1967) the boat is rigged to drift off broadside to the wind and 25 to 35 nylon or cotton lines are trailed out. Each is baited with a crab (Mennipe mercenaria, Callinectes ornatus, or Libinia) and weighted to fish the bottom. When a line comes tight, it is hauled in, the octopus seized and killed by stabbing it in the brain between the eyes. In this fishery, crabs of about 100 g weight are used and the supply often becomes depleted. Brightly coloured artificial lures (señuelos) shaped like the American lobster (Homarus americanus) have been used. The centre part of the back is filled with sponge rubber and this is saturated with fish oil. The lure is used in the same fashion as the natural bait. At this writing statistics are not available on the catch effectiveness of this lure. A variation of this method is to fish in the same fashion (al garete) but to have 5 or more empty shells of Strombus gigas on each line. These, when dragged over the bottom, are seized by the octopus and hauled aboard.

Traps and pots: A few octopus are caught in fish traps set for demersal species of fish and crawfish (Panulirus) but not in any numbers. In Mexico the Italian method of mummarellas is used successfully. In this, strings of pots are set out and the female octopus uses them as refuge and for laying eggs. The method is very successful and permits fishing in times of the year when the animals are living in deeper water. Empty Strombus gigas shells can be substituted. This fishing method requires some exploratory work and is not recommended on muddy bottom.

4.2 Squids

Trawls and seines: By far the greater amount of squid presently landed in the Caribbean region come from shrimp trawls (redes de arrastre de camarones) as a by-product of the shrimp fishery. While this is a fairly efficient way of catching some species, i.e. these that lie on or near the bottom, it is not effective for those in mid-waters or at the surface when they are schooling and thus most susceptible to capture.

Squid are also captured in many areas by the use of beach seines as in Puerto Rico.

Cast nets: In Cuba and in some other areas small numbers of squid are taken with the cast net or atarraya. This is not a very efficient method.

Jigging: Jigging is employed in some areas, particularly in Cuba where the jig is called a potera. This is a lead, spindle-shaped or cone-shaped jig with upward directed barbless hooks on the bottom. It is sometimes baited with salt pork or a piece of white cloth and is fished alongside the boats in the same fashion as in Newfoundland.

Night lighting: In this method the squid are drawn to the surface by bright lights and there taken by a variety of devices. A popular method practised in some areas consists of a bonfire on the beach, drawing squid ashore when they then become stranded. In the Dominican Republic artificial lights are used and the squid are then dip-netted. This is also used in Dominica where a 300-candle power light is used and the squids dip-netted as they come under the light.

In Mexico a variation of this method is employed. The fishermen go out in small rowboats or launches and hang a Coleman lantern over the side. Lines are then put over baited with half-beaks (Hemiramphus). When a squid seizes the bait it is drawn up to the surface and dipped with a hand net. The catch is very small and schools of squids do not appear to be attracted to the light.

5 POTENTIALS OF THE FISHERY

In order for either the octopus or squid fisheries to develop their maximum potential, it is necessary to develop a suitable market. While it has been shown that practically no local market presently exists in some of the countries surveyed, we have the interesting and contradictory situation that octopus and squid in some of these areas bring a higher price on the local market than do many other seafoods. Undoubtedly, a more consistent supply of this resource would open a larger market, but it is also necessary to sell the idea of eating these animals to the general public. In this line, a cookbook for octopus and squid is now being prepared which it is hope will aid in this direction.

Besides the local market, an export market can certainly be developed. There is a large demand for these animals in the Orient and in other parts of Latin America. Companies in Argentina and Chile are now processing these animals and producing a fairly acceptable canned product which, however, is still not as acceptable as the Spanish or Portuguese product. Although no one has yet surveyed, to my knowledge, the market value of the dried squid and octopus imported from Hong Kong to the United States and other areas with large Chinese and Japanese populations, the total must be high. It is mainly dried, a method easily suitable in many Caribbean areas, and brings a high price, averaging about US$2.50-3.00 per kg in the store. Various attempts have been made to produce a quality of dried squid product in California and Newfoundland, with considerable success in the former and dried octopus was formerly exported to the Orient (Philippines) from the U.S.A.

The potential of the fishery itself is difficult to determine. Observers repeatedly report large concentrations of squid throughout the Caribbean, and several fisheries officers with whom I have corresponded have considered that the stocks were sufficient to consider an export-oriented fishery. The loliginid squids in particular are found almost throughout the entire region and in areas school in large quantities. Unfortunately, at the present time reliable figures as to distribution, numbers, places of concentration and seasonal abundance are almost completely lacking.

Studies of the biology of several species (Sepioteuthis sepioidea, Lolliguncula brevis) indicate that these two species at least have a very short growing period, reaching maturity in about six months. Their life span is probably not much more than one or two years. Loligo pealei is presumed to live for two to three years, on the average. Most of them are highly prolific. Of the other loliginids we have little information.

Illex illecebrosus, the arrow squid, prefers cool waters. In New England and Newfoundland they come inshore during the late summer and the fishery is carried out in depths of from 20 to 30 m, the animals often schooling around the fishing boats. However, in our waters they live at depths of 180-450 m in waters of similar temperature. Fishing for these does not seem practicable with present gear unless it can be shown that they come into shallow water on seasonal runs. No information is available on this. These squid are very numerous.

Ommastrephes pteropus is a heavy squid. It is found offshore over the outer part of the continental slope. It occurs in great quantities and appears at the surface at almost every open ocean station within a few minutes of the turning on of an outboard light. They seem to be almost inexhaustible in number and could easily support a large fishery.

Bullis from the research ship OREGON and scientists aboard the PILLSBURY both in the Gulf of Mexico and in the Caribbean Sea have on occasions reported sighting vast schools of squid on the surface at night. In addition, it is known that around the Lesser Antilles, both large and small species of toothed whales concentrate seasonally. As their diet to a large degree consists of squid, it must be presumed that these areas support large stocks of the latter. No direct observations have been made.

The octopus potential is very large. Octopus of several species are commonly found throughout the area both in shallow water and at greater depths. Octopus in general throughout the Gulf and Caribbean come inshore in the autumn and winter months to feed and to spawn and hatch their eggs. The major fishing periods for these species is from October through December with the peak period occurring in November. By April most of the octopus have returned to deeper waters beyond the reach of the presently used gear.

I know of no assessments of the standing stock of octopus in any area. However, the evidence points to large populations. These animals have a short life span, generally not considered to extend past the spawning period but this is based upon aquarium studies and may not hold true in the wild. At all events, the life span probably does not usually exceed one to two years. Most of the possible commercial species lay large numbers of eggs, from a few hundred to 150 000 (Octopus vulgaris). The limit to the populations does not appear to be food but living space. Evidence of their abundance under favourable circumstances is shown in the periodic great octopus invasions of the British coast (Rees and Lumby, 1954) and privately reported occurrences of similar invasions in the upper Gulf of Mexico.

In summary, there can be little doubt that vast potential stocks of octopus and squid occur in the Caribbean Sea and adjacent regions but documentation is not available.

6 RECOMMENDATIONS FOR THE DEVELOPMENT OF THE FISHERIES

6.1 Squid

The present fishery, except for the primitive one at Progreso, Mexico, is based upon the catch accompanying the shrimp catch. As such, it has little likelihood of being greatly increased if maintained on this basis. However, three other major methods have proved highly successful in other areas and are recommended on an experimental basis in our region. The success of these will depend upon a planned programme of fishing in order to determine areas of maximum concentrations at various times of the year.

Nets: When the concentrations of squid are significant on trawlable bottom otter trawling is a proven successful method, but only under certain conditions. For discussions of this method, mesh size, rig, etc., probably the best reference is García Cabrera's work on the experimental cephalopod fishery on the Saharan Bank (García Cabrera, 1968). I doubt, at the present time, if this method would be successful in the Caribbean without extensive exploratory work.

The most successful net fishery for squids that seems adaptable to this region is the use of the lampara net or a modification of it. This has been successfully introduced into the Monterrey Bay region (Fields, 1950) from Spain and Portugal. This fishery may be carried out in conjunction with spawning activities or other schooling and offers a high yield in suitable areas. In small operations, squid are concentrated by the use of electric lights or torches and when in sufficient numbers the net is then put over and surrounds them. Smaller nets do not offer a large investment and would greatly increase the catch.

Night lighting: Considerable fisheries are conducted in the Orient using a light hung over the side of the boat above the surface of the water or submerged. Squid fishermen at Progreso, Mexico, fish primitively in this fashion using Coleman gas lanterns and in Dominica a 300-candle power light is used. The squid are either then caught as they take a baited line or simply dipped up with a hand net.

However, in Japan and the Philippines a 1 000-watt electric light is used to gather the squid in large concentrations. They are then caught by the use of a lure of abalone shell or lead or plastic squid jig pulled through the water from a short line on the end of a hand pole. This method is used for loliginids but primarily for the ommastrephid squid Todarodes pacificus. The system brings the squid Ommastrephes pteropus to the surface quickly and it readily takes a lure. This method, with some experimentation on the type of lure and size, should work well for loliginids in inshore waters. Around the islands of the Lesser Antilles where deep water occurs close inshore, a small boat fishery for O. pteropus could be easily established in many areas with little cash investment and a minimum of exploratory work.

Jigging: Hand jigging for squids, both loliginids and ommastrephids has been a time-honoured fishing method in the North Atlantic where the catch is used almost entirely for codfish bait. Several hundred kg of squid could be taken in an hour by a single fisherman on a good run. This fishery survived only in Newfoundland (Voss, 1967 and unpublished MS) but has now been completely revolutionized by the advent of the Japanese squid jigging machine. This consists essentially of a handcranked reel upon which is wound a series of plastic jigs fastened at intervals on heavy monofilament line. In operation a heavy weight is attached to the end of the line and the line is then run over an outboard roller located above the level of the reel with a chute underneath. The line is let run free down to the desired depth, stopped, and the jigs reeled back in. On a good run, the jigs will each have from one to three or four squids hanging to the hooks. As these are drawn over the roller, the squid drop into the chute and slide into the fish box. In this fashion, a single fisherman can catch upward of 1 000 kg of squid per hour. Experimental boats from the fisheries laboratory in Newfoundland use as many as 4-6 double reels per boat operating with a power take-off from the main engine and worked by a technician who attends the reels, clearing them when required.

Several of these jiggers have been purchased and used at various areas in the Caribbean. They have had little success as yet but this is due, in my opinion, to lack of information as to fishing times and areas. In New England and Newfoundland, the favoured jigging time is from about sunrise to about 10.00 h and from 16.00 h to dark. Jigging is not done by this method at night. The areas in which squid are jigged are remarkably small and selective and jigging only a few hundred yards away from a favoured spot may yield nothing. The causes for this selectivity are as yet not known. As a result, for this fishery to be successful, search has to be made for proper areas where squid are known to congregate, the proper time of the day or early evening must be determined, the schooling depth ascertained, and perhaps some changes made in size of jigs and perhaps in colour, though this last has made little difference in catch in experiments undertaken in Newfoundland. Reel jiggers are simple in construction and after a model is obtained, local fishermen become adept at making their own using locally available materials (small drums for reels, automobile wheels for rollers, etc.). I believe that this type of fishery is adaptable to the Caribbean region and if proved successful, could be instituted on a large scale basis with little initial investment by the fisherman.

6.2 Octopus

The best developed octopus fishery in the Caribbean and Gulf region is centred at Campeche, Mexico. A full report upon the biology of the species, the present method of fishing and experimental fishing is given in the paper by Solís (1967). To supply any market demand it is essential that the hunter method of catching octopus be superseded by a more productive fishing technique.

The al garete or drift method described by Solís is moderately productive and should be a good substitute for reef hunting where the bottom is suitable. Nonetheless, it depends to a certain extent upon the season of the year, usually when the animals are in shallow water in the autumn and early winter. It also requires the full time of the fisherman.

Trap fishing is practised in Italy, the trap or nassa consisting of a wicker trap into which the octopus can enter but cannot leave. It is baited with crabs and can be set down to about 80 metres. The catch is fairly regular and large (Voss, 1960).

Somewhat similar to this fishing method, but taking advantage of the proclivity for octopus to search out holes or caves is mummarella fishing. This consists of setting out large numbers of clay pots tied at intervals of about two m to a long line by means of drop lines. Series of these are then set out in appropriate places. They are not baited. The lines are hauled daily, the fishermen being free the rest of the time to pursue other work. Mummarella fishing has a distinct advantage in that it is not seasonal as the lines can be set in deep water during the long summer season when octopus go to deeper, cooler, less illuminated waters and moved into shallow water during inshore spawning periods.

Where earthenware pots are not available, the West Indian queen or pink conch may be substituted with some advantages. Long lines of two to three hundred shells or more should be set outside the reef or in deeper water of the lagoon from about 2 to 10 m and after seasoning, should be pulled about every other day. It should be expected, in good areas, to have an octopus in about 25 percent of the shells, after the proper depth and type of bottom have been found. Care should be taken to set these on hard bottom (broken shell or sand) or in grass beds. If set on mud bottom the shells usually sink in too deeply and the octopus cannot crawl into them. Only the largest shells should be used in order to attract large animals. Such a fishery requires small initial outlay and can be carried out from even the smallest types of boats.

The commercial octopus fishery on the Saharan Bank has been described by García Cabrera in the paper noted above. This is conducted from stern trawlers using large otter trawls and the catch is very large. The Japanese have added to the efficiency of trawling for octopus by equipping the footrope of the trawls with "octopus lifters". No detailed description of this gear has been found by me but it is pictured and referred to by Sakai (1967). They are somewhat comparable to the shrimp "tickler chains". These were used in trawling operations in waters of about 8 to 25 m in depth. Exploratory fishing with such gear along much of the continental shelf areas of the Caribbean and adjacent areas might well reveal a rich fishery with a high dollar value. The large shelf off the Guyanas might well repay extensive exploratory fishing for these animals dependent upon the season of the year and the depths trawled.

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DYNAMICS OF THE YELLOWFIN TUNA FISHERY IN THE CARIBBEAN REGION[1]

by

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Longliners fishing in the Caribbean region catch at least 10 species of tunas and related fishes. The most important species is the yellowfin tuna which makes up some 60 percent of the catch.

The yellowfin tuna of the Caribbean region as defined by Wise and Jones (this symposium) are probably distinct from the yellowfin tuna of the eastern Atlantic (Wise and Le Guen, in press). The principal fishery for yellowfin tuna in the region has been that of the Japanese longliners, who began fishing in the area in 1956 and who caught an average of about 10 000 metric tons each year from 1958 through 1965 (Wise and Fox, in press). (Japanese longline statistics are usually given in numbers of fish - we have used an average weight of 45 kg to convert numbers to weight.)

The catch of yellowfin tuna by Venezuelan and Cuban longliners - the only other longliners that regularly fish in the region - is estimated at some 5 to 10 percent of the Japanese catch, from published data (Nomura, Paiva, and Buesa M., 1965; FAO, 1967; Griffiths and Nemoto, 1967; Griffiths and Simpson, 1968). We assumed that the well-documented catch per unit effort of the Japanese fleet is representative for the area, and estimated the total catch and effort by raising the Japanese figures 7.5 percent. Table I shows our estimates of catch, effort, and catch per unit effort for yellowfin tuna in the whole Caribbean region for the years 1956-65.

TABLE I

Estimated longline catch and effort for yellowfin tuna
in the Caribbean region, 1956-65

Year	Catch (000 fish)	 (metric tons)	Fishing effort (000 hooks)	Catch/100 hooks (numbers)	 (kg)
1956	13	585	138	9.3	419
1957	60	2 700	939	6.4	288
1958	384	17 280	4 094	9.4	423
1959	283	12 735	4 752	6.0	270
1960	234	10 530	5 189	4.5	203
1961	46	2 070	1 657	2.8	126
1962	341	15 345	12 889	2.6	117
1963	279	12 555	12 741	2.2	99
1964	354	15 930	22 294	1.6	72
1965	254	11 430	18 619	1.4	63

We found that the relation between effort and catch per unit effort in this fishery is best described by a curve (Figure 1). It appears that the abundance of the available population does not decline linearly with increased fishing effort because it becomes increasingly difficult to reduce the population as the fish become scarcer.

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[1] Contribution No. 89, Bureau of Commercial Fisheries, Tropical Atlantic Biological Laboratory, Miami, Florida 33149, U.S.A.

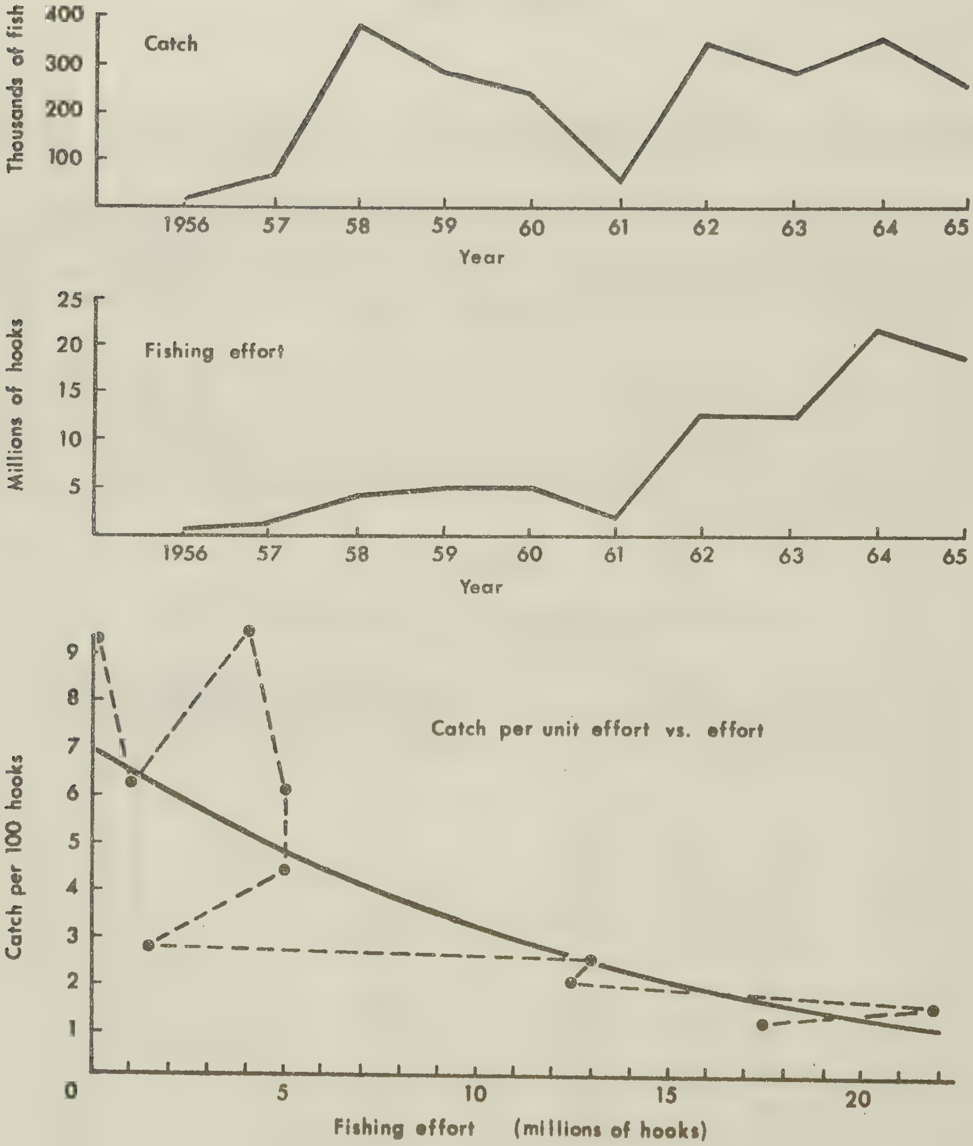

Fig. 1 Yellowfin tuna catch and efforts

As Schaefer (1954, 1957) and Schaefer and Beverton (1963) have discussed, the annual equilibrium catch in a fishery is that average annual catch which will cause the fishable population neither to increase nor to decrease under a given fishing pressure. Under equilibrium conditions the curvilinear relationship between fishing effort and catch per unit effort for the Caribbean yellowfin tuna may be described by the equation:

$$\log U_i = \log u - \log b \, X_i,$$

or

$$U_i = u b^{-X_i}$$

where U_i is the mean annual catch per unit effort (fish per 100 hooks) in year i, u is a measure of abundance of the virgin population before exploitation, b is the rate of decline of the population due to fishing, and X_i is the fishing effort (number of hooks) in year i. The equilibrium catch (C_e) for any level of fishing effort is:

$$C_e = X_i \, U_i.$$

The second equation may be substituted into the third:

$$C_e = X_i \, u b^{-X_i}$$

to estimate the equilibrium catch for any level of fishing effort.

It is unlikely that the longline fishery for yellowfin tuna attained equilibrium during the 1956-65 period, since the fishing effort tended to increase in those years (Figure 1). An estimate of equilibrium conditions can be made, however, by relating the catch per unit effort in year i to the mean of the fishing effort during the time a year-class remains in the fishery (Gulland, 1961; Schaefer, 1967, 1968). Analysis of our data indicates that the best relationship is found between catch per unit effort in a given year and the mean effort in that year and the two preceding years. Thus, we are able to estimate equilibrium conditions by least squares regression of the relationship between average fishing effort and the logarithm of catch per unit effort. The equilibrium line estimated by this method is shown in Figure 2. The equation for this equilibrium line is:

$$\log U_i = 0.8525 - 0.4430 \times 10^{-7} \left(\frac{X_i + X_{i-1} + X_{i-2}}{3} \right)$$

This equation may be substituted into the equation which estimates the equilibrium catch for any level of fishing effort. The result is the equilibrium curve shown in Figure 3 together with the actual effort and catch data for 1956-65. Each point on the equilibrium curve represents the average number of fish which would be caught at a given level of fishing effort maintained for several years under relatively stable environmental conditions.

When the theoretical equilibrium catch curve is compared with actual effort and catch data (Figure 3), the curve appears to correspond reasonably well with the trend of the actual data. Most of the data points fall above the curve because the effort has tended to increase from one year to the next; in brief periods of fairly stable effort (1958-1959-1960, 1962-1963) the points approach the curve; in the unique drastic reduction of effort (1961), the point falls below the curve.

Strict confidence limits for the equilibrium line are difficult to calculate, partly because we have estimated the total catch and effort of the longline fisheries. We believe that ±25% over most of the range of the equilibrium curve is not unreasonable.

Some implications of our study are clear:

1. The Caribbean region has a considerable resource of yellowfin tuna capable of yielding to the longline fishery about 260 000 fish annually, weighing about 10 000 metric tons. (Our estimates are based on numbers of fish; the maximum yield in weight may be somewhat higher.)

2. The maximum sustainable yield in numbers can be realized with a fishing effort of about 10 million hooks. The maximum sustainable yield in weight may be attainable with less fishing effort.

3. Although the level of fishing effort in 1964-65, about 20 million hooks a year, will not endanger the yellowfin tuna stocks, continued fishing at this level should cause catches to decrease markedly before they stabilize. Therefore, any reduction of fishing effort of about 80% or less would

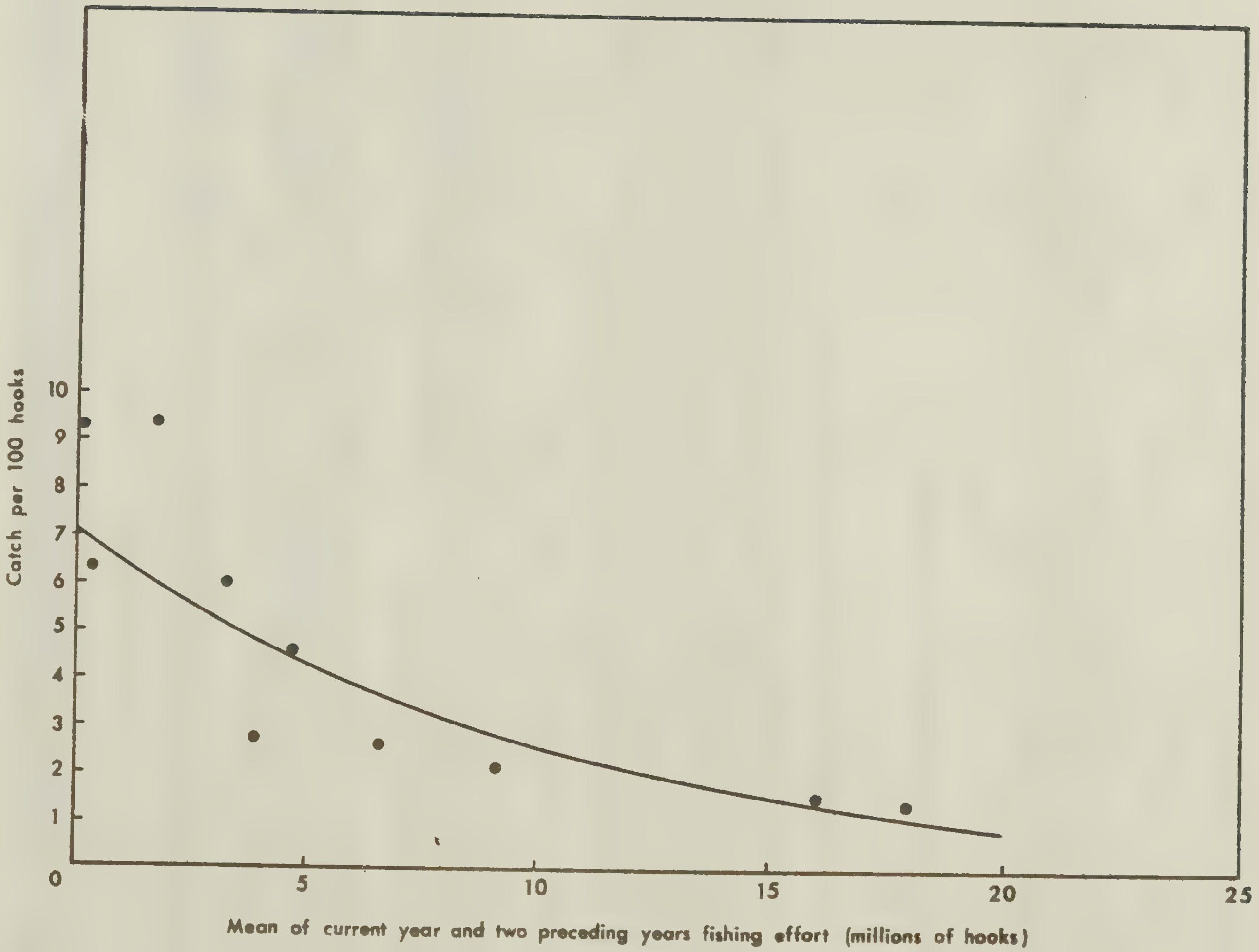

Fig. 2 Estimated equilibrium of fishing effort and catch per unit effort

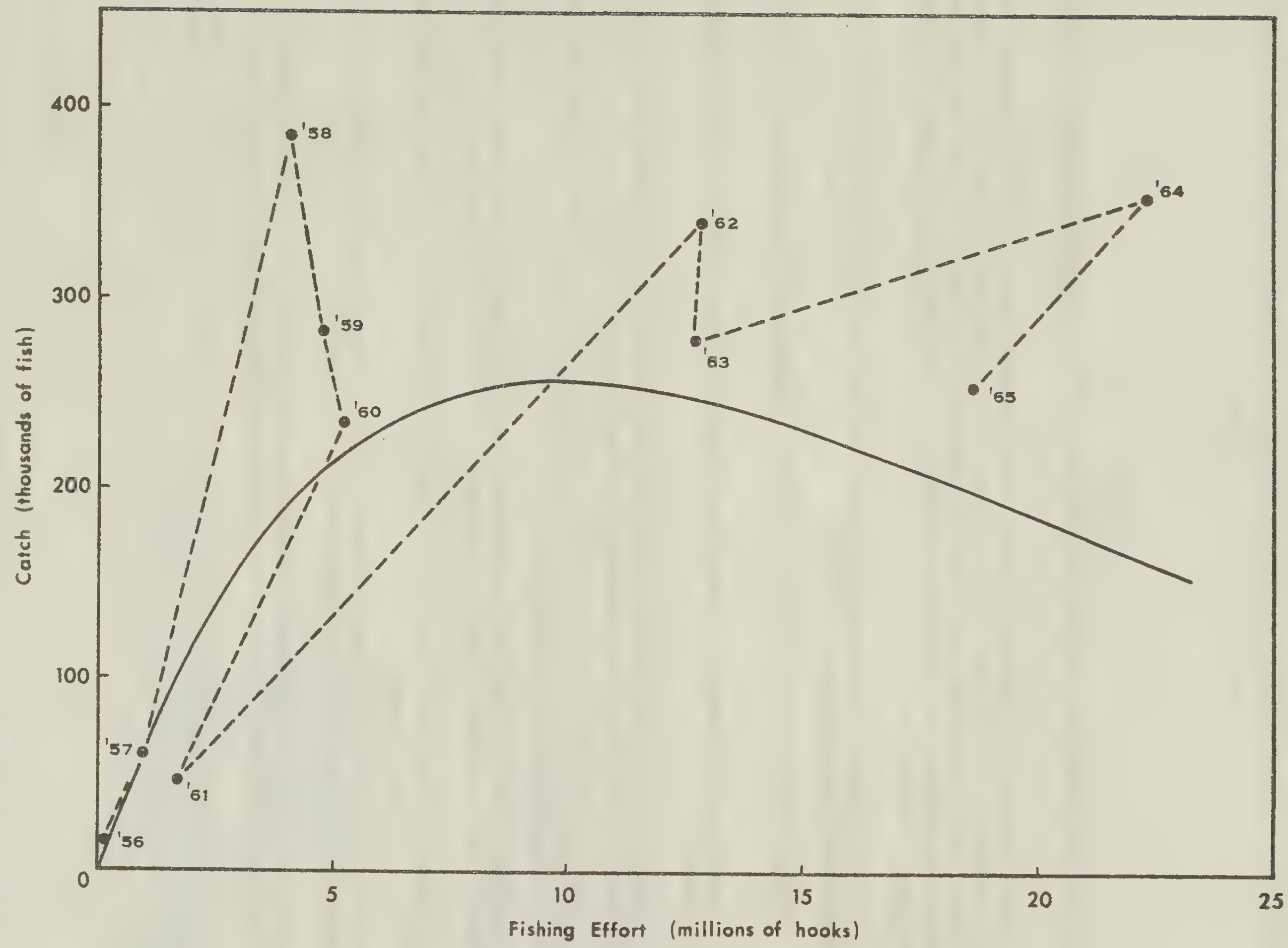

Fig. 3 Equilibrium relation between fishing effort and catch

probably increase catches over the long term. Any reduction of fishing effort from the 1964-65 level will almost certainly increase the catch per 100 hooks; a reduction to 10-15 million hooks annually should double the catch per 100 hooks.

4. As long as the major fishery for yellowfin tuna in the Caribbean region is carried on by a country or countries not bordering the region the Caribbean countries can do little to influence catch rates.

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TUNAS AND TUNA FISHERIES OF THE CARIBBEAN REGION[1]

by

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1 INTRODUCTION

The only sure thing about defining the Caribbean region for oceanographic or biological purposes is that it must include more than the Caribbean Sea, because it is so closely linked with the Gulf of Mexico to the north and with the waters off the northern coast of South America to the east. We have followed Wise and Le Guen (1969) in defining the Caribbean region as the Gulf of Mexico, Caribbean and Guianas areas, and parts of adjacent areas (Figure 1). The definition is arbitrary, as all such definitions must be, and is based principally on the Japanese longline fishery, the major fishery for tunas and related species in the western Atlantic. Japanese catch and effort statistics are reported in 5° rectangles of longitude and latitude; therefore, certain arbitrary choices were dictated.

Several tunas and related species occur in the Caribbean region:

Yellowfin tuna	-	*Thunnus albacares*
Bigeye tuna	-	*Thunnus obesus*
Skipjack tuna	-	*Katsuwonus pelamis*
Blackfin tuna	-	*Thunnus atlanticus*
Bluefin tuna	-	*Thunnus thynnus*
Albacore	-	*Thunnus alalunga*
Little tuna	-	*Euthynnus alletteratus*
Frigate mackerels	-	*Auxis* spp.
Blue marlin	-	*Makaira nigricans*

Members of the genera *Xiphias*, *Acanthocybium*, *Sarda*, *Istiophorus*, *Makaira*, and *Tetrapturus* are found in the area and occur in varying but relatively insignificant quantities in the catches. The list is not peculiar to the region, but could be applied to the whole tropical Atlantic or even in general to other tropical and sub-tropical seas.

2 THE TUNA FISHERIES

Total annual landings of tunas from the Caribbean region are estimated at 28 800 metric tons. (This and following estimates are for 1965, the latest year for which complete figures are available. The basic source of information on landings is the FAO Yearbook of Fishery Statistics, 1967.)

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[1] Contribution No. 94, Bureau of Commercial Fisheries, Tropical Atlantic Biological Laboratory, Miami, Florida, U.S.A.

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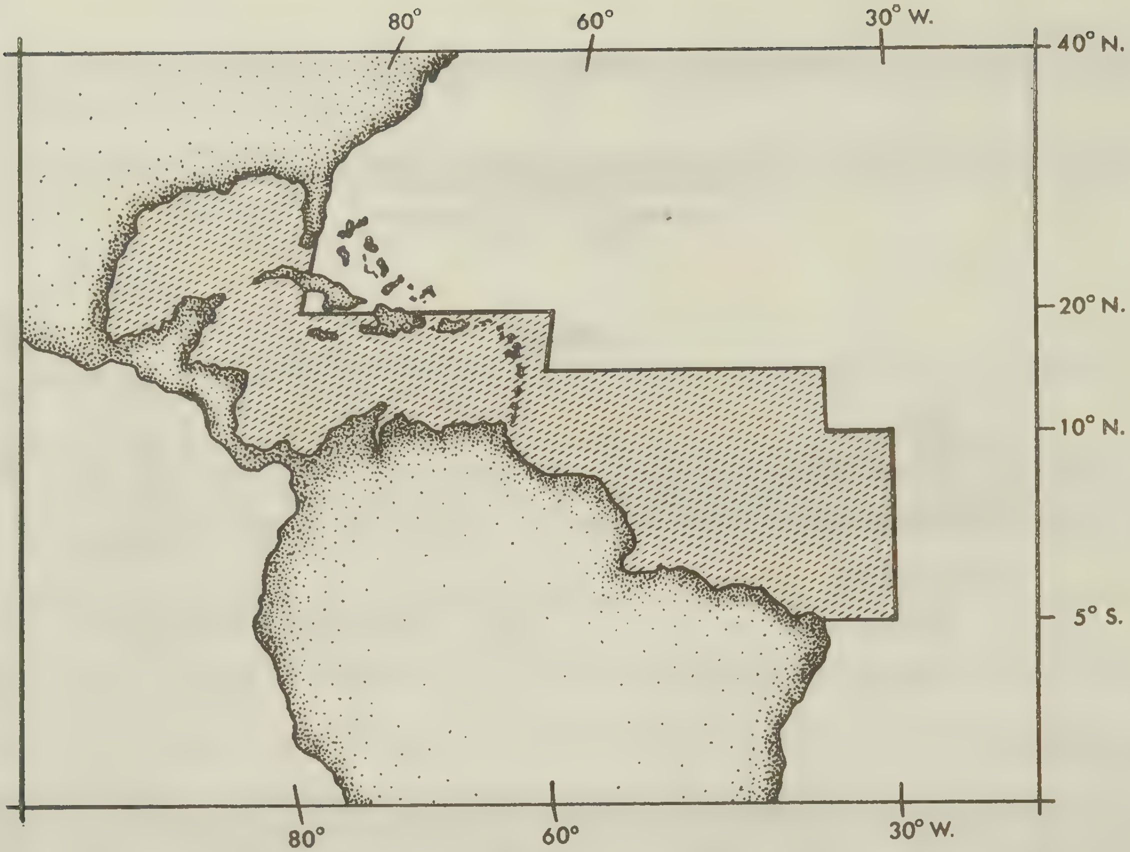
80°
60°
30° W.
40° N.
20° N.
10° N.
5° S.
80°
60°
30° W.

Fig. 1 The Caribbean region (shaded area) as used in this study

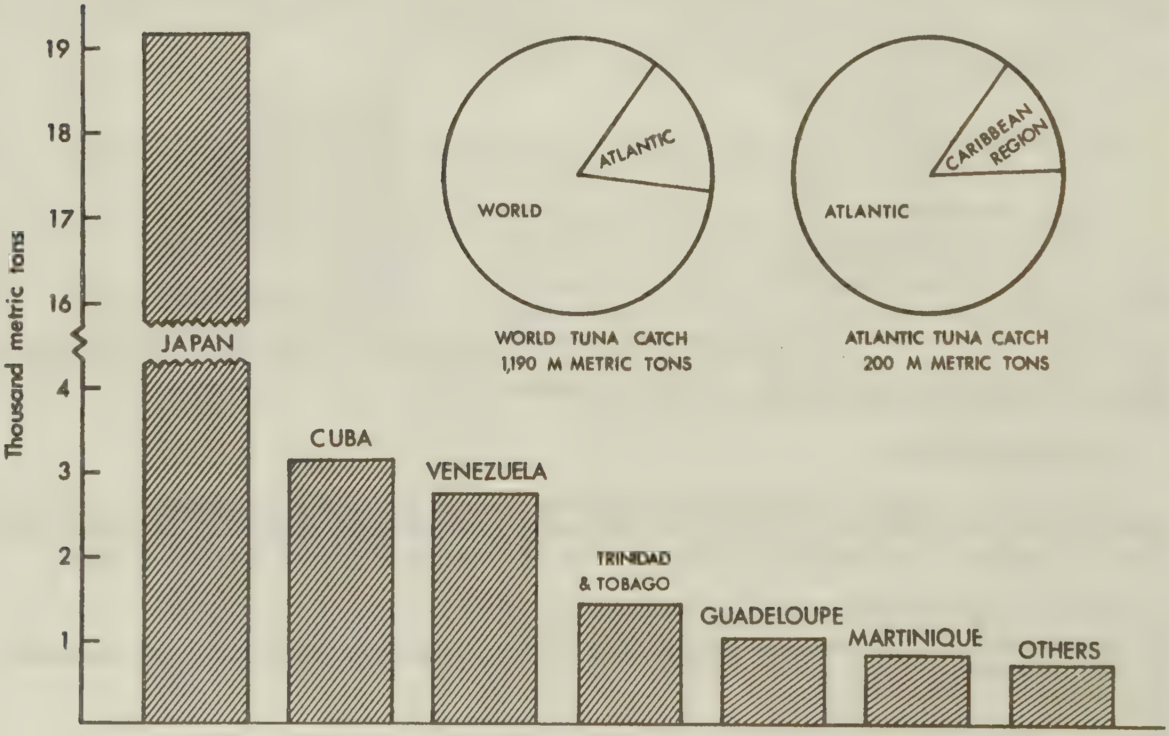

Fig. 2 Catches of tunas in the Caribbean region, by countries

Total landings of tunas and related species from the whole Atlantic are about 200 000 metric tons annually. The production of the Caribbean region is about 14 percent of all Atlantic landings and about 2 percent of the world landings of some 1 190 thousand metric tons.

The catch in the Caribbean region is shared by several countries (Figure 2). Japan takes about two thirds and Cuba and Venezuela each take about a tenth. The remainder is divided among several countries and regions, each of which takes less than 2 000 tons annually. (Landings shown for Trinidad and Tobago may be largely those of Japanese longliners and thus may be represented twice.)

Yellowfin tuna, the most important of the exploited species of tunas in the Caribbean region contributes slightly over one third of all landings (Figure 3). Second is a group of smaller tunas which we refer to for convenience as "bonitos", as they are called in many Caribbean countries. These "bonitos" probably include few true bonitos but are made up largely of skipjack tuna and blackfin tuna, with a small admixture of other species such as little tuna and Auxis. Third in importance is bigeye tuna, followed by bluefin tuna and albacore.

As might be expected, the distribution of the species in the catches is strongly influenced by the important Japanese longline fishery. When the Japanese figures are removed from the catch statistics, the "bonitos" are by far the dominant species, contributing more than four times as much as all other species combined (Figure 3).

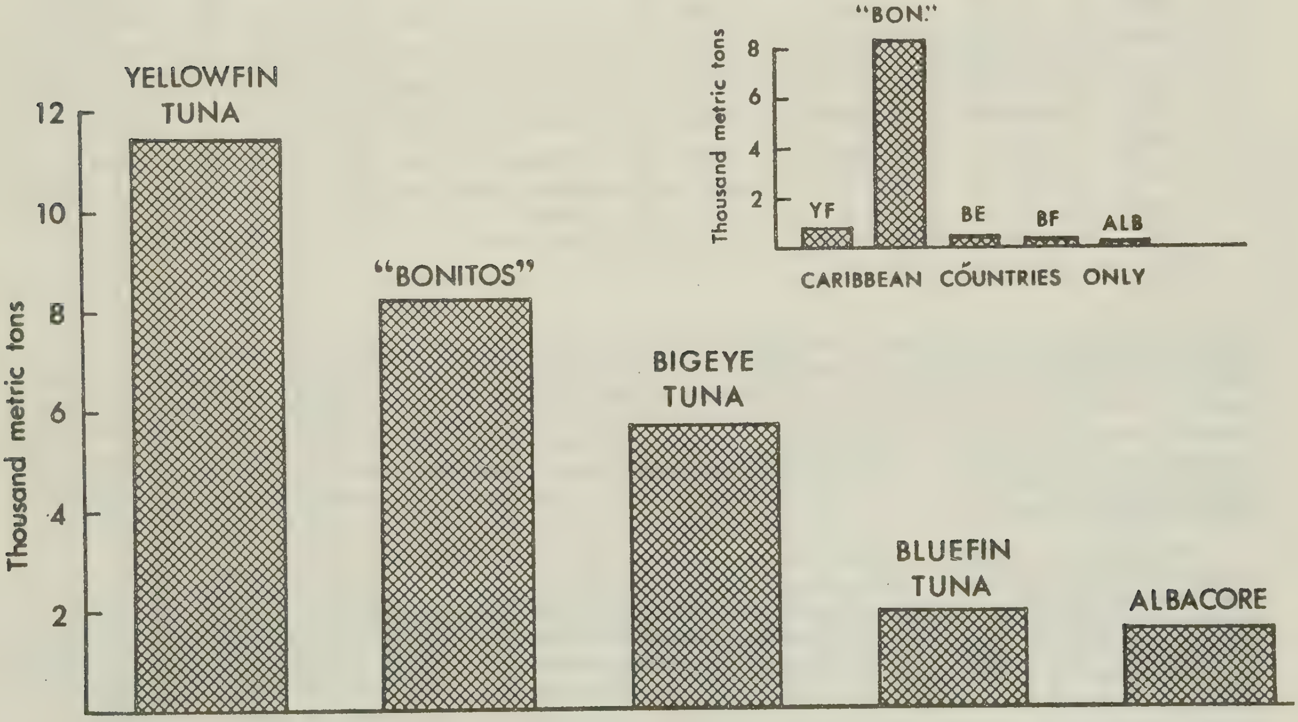

Fig. 3 Catches of tunas in the Caribbean region, by species

2.1 The longline fishery

Table I shows the estimated fishing effort plus the catches of various species by the Japanese, Cuban, and Venezuelan longliners fishing in the Caribbean region in 1956-65. (Longliners from South Korea and China (Taiwan) are now based at Saint Martin Island and undoubtedly do some fishing in the Caribbean region.) These estimates were made by taking the statistics published by Shiohama, Myojin, and Sakamoto (1965) and by the Japan Fisheries Agency (1966, 1967, 1967a) for the region, adjusting for the sampling of the logs of the Japanese fleet, and raising the figures by 7.5 percent to include the Cuban and Venezuelan longline fleets (Wise and Fox, this symposium). The original statistics, which were in numbers of fish, were converted to weights by multiplying by the average weight of each species for the Atlantic Ocean (Japan Fisheries Agency, 1967a, Appendix Table 3).

TABLE I

Longline fishing effort (thousands of hooks)
and catches (metric tons) in the Caribbean region, 1956-65

Year	Thousands of hooks	Yellowfin tuna	Bluefin tuna	Bigeye tuna	Albacore	Blue marlin	Other fish
1956	138	585	0	10	21	48	2
1957	939	2 700	18	120	281	206	35
1958	4 094	17 280	8	222	1 121	338	54
1959	4 752	12 735	116	751	1 270	457	47
1960	5 189	10 530	484	780	1 203	579	114
1961	1 657	2 070	267	536	269	195	76
1962	12 889	15 345	8 172	3 625	2 129	1 536	810
1963	12 741	12 555	5 739	3 331	1 761	1 270	910
1964	22 294	15 930	4 707	4 784	2 591	2 797	1 930
1965	18 619	11 430	1 963	5 710	1 530	1 437	1 807
Total	53 312	101 160	21 474	19 869	12 176	8 863	5 785

0 = Less than 0.5 metric tons

Table II shows the estimated catch per unit of effort in numbers of fish per 100 hooks for the major species taken by longline in the Caribbean region in 1956-65. The trend for yellowfin tuna and albacore is one of increasing effort, with catch increasing at a much lower rate; the result is a reduced catch per unit of effort. A similar situation has been reported in detail for the whole Atlantic Ocean by Wise and Le Guen (1969), Le Guen and Wise (1967), Wise (1968), and Wise and Fox (1969). Wise and Fox (this symposium) showed that the major species - yellowfin tuna - is probably being overfished by the longliners in the Caribbean region and that fishing effort should be reduced to about half the 1964-65 level.

The Venezuelan longline fishery was described in some detail by Griffiths and Nemoto (1967) and Griffiths and Simpson (1968). The fishery began about 1954 and is now carried on by about 40 small local vessels plus the original three "Japanese" vessels. The carrying capacity of the boats in the fleet varies from 3 to 150 tons. The annual catch for 1960-66 averaged about 2 400 metric tons. The distribution of the species in the catch is undoubtedly similar to that in catches of the Japanese longliners working in the same region, although some variation would be expected because the distribution of fishing areas and the bait used differed. The range of the fishery is limited; vessels rarely fish outside the area between 45° W and 75° W, or north of 20° N. In fact, because a substantial part of the Venezuelan fleet is made up of small vessels, most of the fishing is probably concentrated in the south-eastern Caribbean Sea. Some of the smaller longliners occasionally fish for species other than tunas.

TABLE II

Catch (per 100 hooks) of major species by longliners in the Caribbean region, 1956-65

Year	Yellowfin tuna	Bluefin tuna	Bigeye tuna	Albacore	Blue marlin
1956	9.3	0.0	0.1	0.8	0.4
1957	6.4	0.0	0.3	1.6	0.2
1958	9.4	0.0	0.1	1.4	0.1
1959	6.0	0.0	0.3	1.4	0.1
1960	4.5	0.1	0.3	1.2	0.1
1961	2.8	0.1	0.6	0.9	0.1
1962	2.6	0.3	0.6	0.9	0.1
1963	2.2	0.3	0.5	0.7	0.1
1964	1.6	0.2	0.4	0.6	0.1
1965	1.4	0.1	0.6	0.4	0.1

Note: "0.0" means a catch of less than 0.05 fish per 100 hooks

The Cuban longline fishery was described by Buesa (1964) and by Nomura, Paiva and Buesa, (1965). Operations began in 1963, when five longliners constructed in Japan began fishing for Cuba in the Caribbean region with Japanese crews. (A small amount of fishing was done outside the region as defined in the present paper.) Catches averaged about 1 000 metric tons a year; the species distribution presumably was the same as in the catch of the Japanese longliners fishing in the same areas.

A longline fishery by U.S. vessels operated briefly in the Gulf of Mexico in the late 1950's; catches, mostly yellowfin tuna, were only 300 metric tons a year at the maximum.

2.2 Surface fisheries

All other important fisheries for tunas in the Caribbean region are surface fisheries and most of them use live bait methods.

The Cuban surface fishery for "bonitos" was described in detail by Suarez and Duarte (1961). The fishery began in the early 1930's; since the 1950's it has produced just over 1 000 metric tons a year. More than 60 percent of the total catch is blackfin tuna, about 30 percent skipjack tuna, and the miscellaneous species, including Auxis and a small amount of yellowfin tuna.

The Cuban fishery is carried on mostly on the south-west coast of Cuba in and around the Gulf of Batabano, by motorized sailing vessels less than 15 m long. Each boat uses a crew of about seven men who fish surface schools with live bait and barbless hooks. The fishery, which is not markedly seasonal, goes on for 10 or 11 months of each year.

Morice and Cadenat (1952) and Morice (1958) mentioned that tunas and "bonitos" are caught by trolling, drifting, handlining and beach seining around Martinique and Guadeloupe. Catches seem to be mostly blackfin tuna and little tuna, and lesser quantities of skipjack tuna and yellowfin tuna. (Morice and Cadenat's "Parathunnus obesus" is almost certainly referring to Thunnus atlanticus.) In recent years the production from each island has been about 1 000 metric tons annually.

Da Cruz and Paiva (1964) and Da Cruz (1965) described the fishery for blackfin tuna in north-eastern Brazil, which takes place in October through January of each year. The fishery is prosecuted by sailing boats less than 10 m long, each with two trolling lines. Landings are small, e.g. less than 100 tons in Baia Formosa each year. The catch is almost exclusively blackfin tuna, but an occasional bigeye tuna is caught.

Morice (1958) mentioned that experimental live bait fishing around Haiti in 1957 was successful, but statistics for recent years do not reveal that the initial effort was followed up.

3 RESEARCH AND EXPLORATORY FISHING

Iwamoto (1965) summarized the results of 14 years of exploratory fishing and scouting for tunas in the Gulf of Mexico by the OREGON of the Bureau of Commercial Fisheries, 1950-63. Yellowfin tuna and bluefin tuna were found by exploratory longlining, especially off the Mississippi River Delta and in the Gulf of Campêche. On the basis of this exploration a short-lived U.S. longline fishery for yellowfin tuna operated in the Gulf of Mexico in the late 1950's.

Iwamoto concluded, however, that the best potential commercial fishing for tunas in the Gulf of Mexico was in surface fishing, preferably by purse seine, for blackfin tuna and skipjack tuna. (Little tuna also were found in large numbers, but Iwamoto believed that their commercial value was limited.) He showed the locations of sightings of surface schools of these species by quarters of the year. Most of the sightings were concentrated in the northern Gulf of Mexico between the 100- and the 1 000-fm contours, but this distribution may have been a function of the distribution of cruise tracks as much as of the fish.

Since 1959 the U.S.S.R. has been active in exploratory fishing and research directed at tunas in the Atlantic. In 1963-65, the U.S.S.R. alone and the U.S.S.R. with Cuba conducted longline exploratory fishing and fishery oceanographic research in the Caribbean region. The results of these expeditions were reported by Sal'nikov (1965), Sokolov (1965), and Zharov (1965).

The Tropical Atlantic Biological Laboratory in Miami has devoted all or part of five fishery-oceanographic cruises to the Caribbean region since mid-1965. Fishing success has been moderate to poor - it has proved much easier to sight schools of tunas than to catch them by surface fishing with live bait.

Since late 1966 the United Nations Development Programme/Food and Agriculture Organization Caribbean Fishery Development Project (based in Barbados) has been doing exploratory fishing with three vessels in the Caribbean region, as part of a plan for fishery development. A substantial part of the exploratory fishing programme has been devoted to longlining and surface fishing for tunas, mostly around Jamaica, Hispaniola, and Puerto Rico, and in the Lesser Antilles from Martinique south to Trinidad. Other explorations have been made along the Caribbean coast of Venezuela and around Aves Island. Results have been similar to those obtained by the Tropical Atlantic Biological Laboratory in mostly the same areas. Reasonably large concentrations of tunas - yellowfin, skipjack, and others - have been sighted, but generally the schools have been "wild" and response to live bait fishing has not been especially encouraging.

Experimental fishing is presently being carried out in the Caribbean and nearby areas by a purse seiner from the U.S. West Coast, chartered by the Government of Puerto Rico, but no results have yet been reported.

Synopses of the biology of many of the important tunas of the Caribbean region have been published in the Proceedings of the World Scientific Meeting on the Biology of Tunas and Related Species (FAO, 1963).

4 CONCLUSIONS

The tuna fisheries of the Caribbean region are of two distinctly different types. One is the high seas longline fishery, based principally on yellowfin tuna, bluefin tuna, bigeye tuna, and albacore. The longline fishery is carried out primarily by Japanese, Cubans, and Venezuelans. The second type is the near-shore surface fishery (principally in Cuba and the Lesser Antilles), based on "bonitos" - in actuality mostly skipjack and blackfin tunas.

Prospects for the enlargement of the longline fishery are not promising - in fact evidence is very good that for maximum sustained yield of yellowfin tuna, the principal species, the amount of fishing should be reduced.

Whether large-scale surface fisheries like those in the eastern Pacific and West Africa fisheries could succeed in the Caribbean region is open to question. Some answers should be furnished by the present purse seine fishing by the Puerto Rican Government. There can be no doubt, however, that surface fisheries to take fish for local consumption and perhaps for modest exports are feasible in many Caribbean regions.

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CONDICIONES OCEANOGRAFICAS Y PESCA DE LOS ATUNES EN EL PERIODO DE INVIERNO EN EL MAR CARIBE

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1 INTRODUCCION

En la actualidad, el desarrollo de la pesca oceánica plantea a la ciencia pesquera como tarea fundamental la determinación de las zonas más productivas del océano y la posibilidad de explotar sus recursos pesqueros.

En lo que respecta al Mar Caribe, el número de observaciones oceanográfico-pesqueras realizadas con anterioridad al inicio de nuestros trabajos es relativamente pequeño. Estas observaciones se realizaron esporádicamente y tenían, en lo fundamental, el carácter de reconocimientos.

Esto, entre otras causas, motivó el que se señalara esta región como de pocas perspectivas para el desarrollo de la pesca pelágica en mar abierto y principalmente en lo referente a los túnidos.

La falta de argumentos para semejante afirmación resultó evidente ya en 1963-64, al organizarse la flota atunera cubana. En el período enero-abril de 1963-66, se iniciaron las capturas de atún en las partes central y occidental del Mar Caribe en forma esporádica por uno o dos atuneros. Al mismo tiempo, se iniciaron los trabajos de pesca exploratoria de investigación oceanográfico-pesquera que proporcionaron los primeros datos sobre la productividad pesquera de algunas regiones del Mar Caribe.

El personal científico del proyecto "Atún" del Centro de Investigaciones Pesqueras del Instituto Nacional de la Pesca de la República de Cuba, ha analizado los datos obtenidos en las pesquerías de túnidos durante el periodo 1963-66, así como el resultado de las investigaciones oceanográficas y de exploración pesquera en el Mediterráneo Americano. Actualmente, estas investigaciones se continúan, estando dedicadas a ellas un grupo de especialistas de diferentes ramas que estudian esta pesquería en sus diversos aspectos.

2 MATERIALES Y METODOS

La base del presente trabajo la constituyen los resultados de las investigaciones oceanográficas y de los trabajos exploratorios con palangre realizados en febrero-abril de 1968 en el Mar Caribe. Durante el análisis de los datos, también se emplearon los obtenidos durante los reconocimientos oceanográficos realizados en octubre de 1967 y noviembre-diciembre de 1965.

Los datos oceanográficos se colectaron siguiendo la metodología habitual. Se determinó la temperatura, salinidad, y el contenido en oxígeno disuelto y fosfatos del agua. En los niveles standard: 0, 25, 75, 100, 150, 200, 300, 500 y 750 metros. También se determinó la profundidad del límite superior de la termoclina. Los trabajos exploratorios con palangre se realizaron en los lugares con las características oceanográficas mas propicias. Conjuntamente con la selección de las estaciones de trabajo para la pesca con palangre se trató de obtener información pesquera general de toda la zona investigada. La pesca del atún se hizo utilizando un palangre con una curva catenaria regulada, en las horas de la mañana. La cantidad de anzuelos colocados en el palangre habitualmente fue de 250-350, y como carnada se empleó la saira, Cololabis saira.

En la elaboración de los datos oceanográficos en el laboratorio se emplearon los métodos propuestos por N. Zubov, para la clasificación de las masas de agua: N. Zubov y O. Mamayev, para el levantamiento de cartas de la topografía dinámica; Hesselberg y Sverdrup, para la estabilidad vertical de las masas de agua.

3 RESULTADOS

Desde el punto de vista del oceanógrafo, el Mar Caribe es una cuenca parecida al tipo de los mares "intercontinentales", alargada en sentido latitudinal. La acción de los vientos de dirección este está determinada rigurosamente en el tiempo y las comunicaciones con el Atlántico y el Golfo de México son suficientemente abiertas. No hay muy grandes profundidades oceánicas y en algunos lugares falta por completo la plataforma continental.

Todo esto es favorable a la estabilidad de los procesos dinámicos, que determinan la situación de las zonas productivas, y, correspondientemente, de las concentraciones comerciales de atunes.

El Mar Caribe está ubicado por completo en la zona tropical. El clima es muy estable y se determina, fundamentalmente, por la intensidad del alisio noroeste.

A diferencia del Golfo de México, donde se observa una deriva constante de las aguas del este al oeste, provocada por los vientos alisios de dirección noroeste y este, las aguas atlánticas penetran al Mar Caribe a través de un estrecho entre las Antillas Menores y Mayores y forman la Corriente del Caribe, la cual al principio se dirige hacia el oeste, luego hacia el noroeste y entra al Golfo de México a través del Estrecho de Yucatán.

Las características de la capa activa, térmica o hidroquímica se generan en el océano abierto, y sólo sufren cierta transformación en el Mar Caribe. Para obtener una idea de los tipos de masas de agua, la región investigada fue convencionalmente dividida en tres zonas: a, b y c (véase figuras). La división indicada se realizó en base a estimaciones de la ubicación de los supuestos centros de procesos dinámicos, que influyen en la distribución espacial de las características oceanográficas más importantes. En base a los valores existentes de temperatura y salinidad para toda la región fue elaborado un diagrama "TS" y para cada una por separado fueron elaboradas curvas "TS". Los grupos de puntos de cada zona están limitados por segmentos de línea recta y forman los epicentros de las masas de agua. Para la determinación de la distribución vertical de las masas de agua se empleó el método de trazado de los extremos en la curva "TS", correspondientes a cada masa de agua.

Como resultado del análisis del material hidrológico disponible, se puedan separar tres tipos de masas de agua en el Mar Caribe:

(1) aguas superficiales, que se caracterizan por un valor máximo de temperatura (hasta 27°C) y por una salinidad comparativamente baja (35,5 - 36,5°/oo).

(2) masa de agua subtropical intermedia, cuyo índice característico es una salinidad media máxima de alrededor de 37°/oo.

(3) masa de agua profunda de origen antártico, que se caracteriza por una salinidad media mínima de alrededor de 34,7°/oo.

Las capas de agua más profundas no se analizan aquí.

A pesar de que la distribución vertical de las masas de agua se ha determinado en forma aproximativa, se puede señalar que en el período de tiempo examinado, las aguas profundas de origen antártico que se supone representan la principal reserva de sales nutritivos, se observan más próximas a la superficie en las zonas a y c, principalmente en la parte sur del Mar Caribe.

Este fenómeno, relacionado con la actividad de los procesos dinámicos, se puede observar en las cartas de distribución horizontal de los valores observados de temperatura y de fosfatos (Figuras 1 y 2). La temperatura del agua en la capa de 0-50 m cambió poco en toda la zona investigada, variando entre 25 y 26°C. Una causa de este fenómeno es el efecto de la acción de los alisios, cuya fuerza en febrero-abril a menudo alcanza los valores máximos. Algún aumento de la temperatura en 0,5 - 0,7°C, se observó en el margen suroccidental de la región. Un efecto de la acción del viento son también los

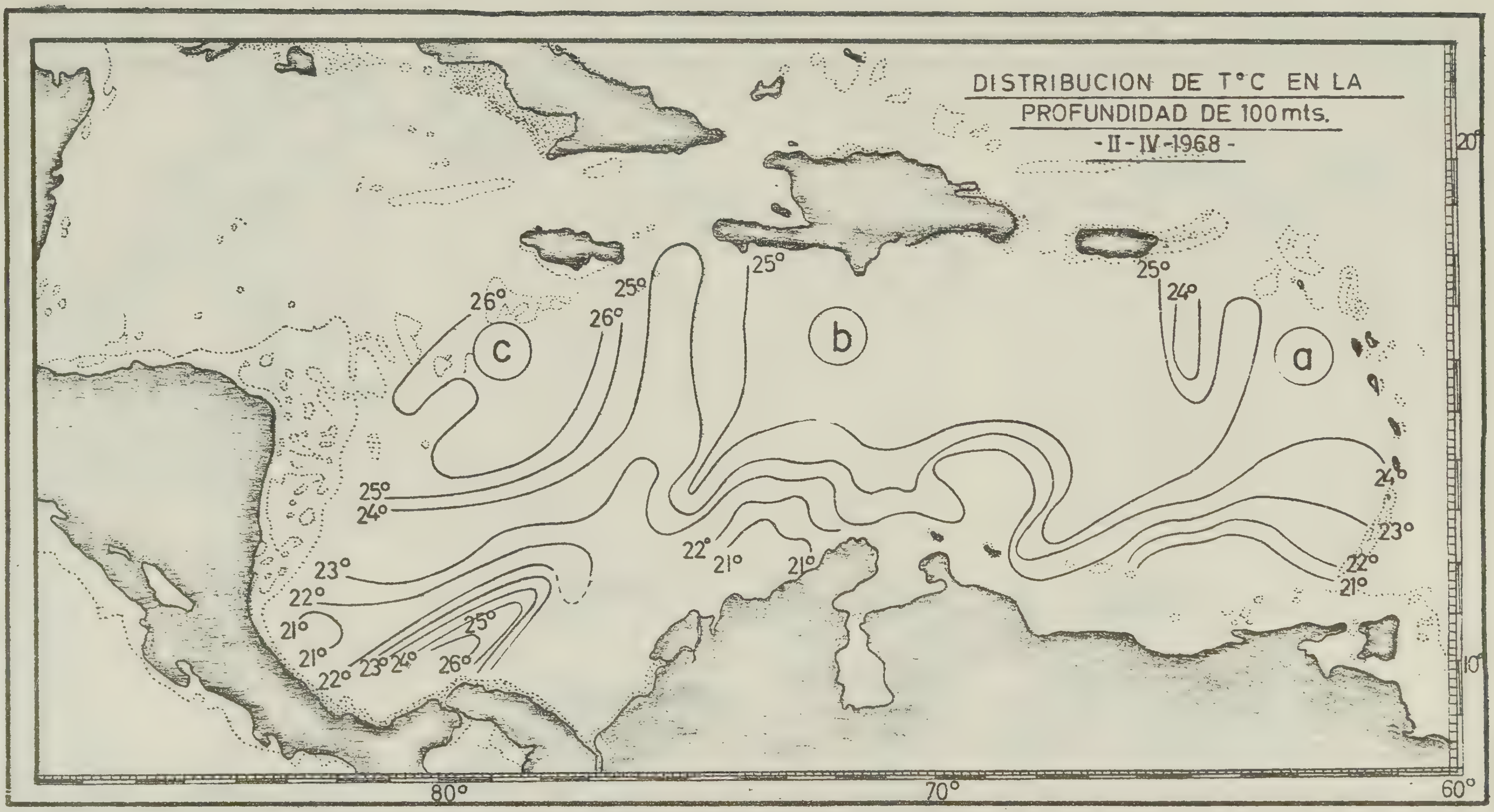
DISTRIBUCION DE T°C EN LA
PROFUNDIDAD DE 100 mts.
-II-IV-1968-
a
b
c
26°
25°
24°
23°
22°
21°
20°
10°
80°
70°
60°

Fig. 1 Distribucion de T° C en la profundidad de 100 m
Febrero-Abril 1968

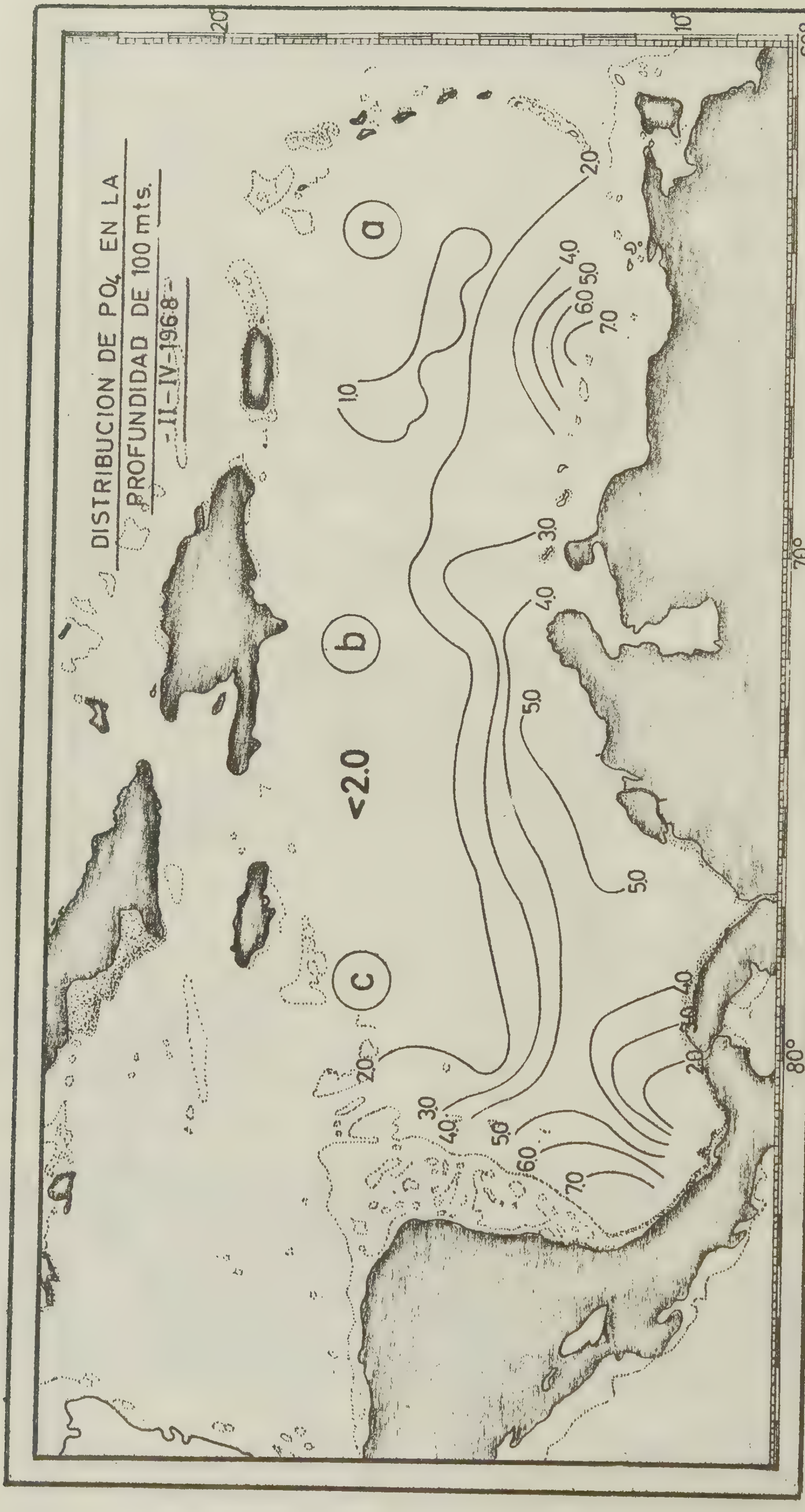
DISTRIBUCION DE PO4 EN LA
PROFUNDIDAD DE 100 mts.
-II-IV-1968-
a
b
c
<2.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
20°
10°
60°
70°
80°

Fig. 2 Distribucion de PO$_4$ en la profundidad de 100 m
Febrero-Abril 1968

valores practicamente constantes de la capa de 0 - 50 m de salinidad, oxígeno disuelto y fosfatos (35,5 - 36,0^{o}/oo, 4,7 - 4,9 ml/l, 1 - 2 microgr P/l respectivamente).

Los rasgos específicos de la distribución horizontal de las características oceanográficas observadas son típicos, en nuestra opinión, para el periódo de invierno. El cuadro se presenta en forma diferente en el nivel de los 100 metros. El oxígeno y la salinidad sufren los menores cambios, mientras que los mayores son experimentados por la temperatura y el contenido en fosfatos. Las regiones de temperaturas bajas con un contenido alto de fosfatos están localizadas en la parte sur del Mar Caribe. La presencia de estas regiones de baja temperatura, atrae hacia la superficie las aguas profundas caracterizadas por un alto contenido de sales nutritivos. Los procesos dinámicos en las aguas del Mar Caribe se determinan por el sistema de corrientes condicionado por el relieve del fondo, la configuración de las costas, y el régimen de vientos predominantes. Una idea general de los desplazamientos horizontales de las masas de agua se obtiene de las cartas de la topografía dinámica (Figura 3).

Una rama de la Corriente del Caribe, dirigida de este a oeste, atravieza la parte sur de la cuenca, dividiéndola en dos zonas diferentes. La zona norte, grande en tamaño, está ocupada por amplias formaciones anticiclónicas, que provocan el hudimiento de las aguas. El anticiclón más profundo está situado en la parte noroccidental del Mar Caribe al sur de Jamaica. Los procesos de despazamiento en este lugar son más intensos que en las otras regiones. Los valores de la estabilidad vertical están expresados en las unidades convencionales E.10^8 para profundidades mayores de 2 000 (Figura 4). De acuerdo con nuestras observaciones, la capa de aguas productivas vecina a las costas al sur del Mar Caribe, descubierta por otros investigadores, consta de una serie alternada de torbellinos ciclónicos y anticiclónicos de las aguas.

Es característico que en las regiones ciclónicas los valores de la estabilidad vertical de las aguas, sean en regla general, máximos. Los límites superiores de la termoclina y haloclina están próximos entre sí, y se sitúan muy claramente cerca de la superficie. El afloramiento más intensivo de las aguas, provocado por el torbellino ciclónico, se observa en la región suroccidental de la cuenca. La estabilidad aquí es la máxima (más de 6 000 unidades convencionales); sólo en esta región y a profundidades de 500 m se encontró aguas propiamente atlánticas.

Retornando al sistema de torbellinos alternos ciclónicos y anticiclónicos de las aguas, es necesario señalar que este fenómeno confirma la hipótesis sobre la creación de las zonas productivas a lo largo del límite izquierdo de la corriente. Indudablemente influyen también en este fenómeno el relieve del fondo y la configuración de la costa, lo cual es especialmente evidente en la zona surocoidental del Mar Caribe.

Al analizar los resultados de los trabajos de pesca con palangres, cabe señalar la regularidad general en la distribución de las capturas (Figura 5). Prácticamente en toda la parte norte y parcialmente en la oriental del Mar Caribe no se obtienen capturas de importancia comercial. Rendimientos mayores de 100 kg por 100 anzuelos del palangre comercial, sólo se señalan en las regiones sur del Mar Caribe, alcanzando los valores máximos en su margen suroccidental. El 40 - 60 por ciento de las capturas consta de atún de aleta amarilla (Neothunnus albacares, Lowe) adulto, y el resto de grandes peces aguja (Makaira ampla), de agujas de abanico (Istiophorus cavalla, Cuvier) y de una pequeña cantidad de diferentes especies de tiburones. El espesor de la capa abarcada por el palangre varió entre 0 - 140 y 0 - 160 metros. La profundidad de calado de los anzuelos (en un palangre con curva catenaria regulada) se eligió en base a las profundidades óptimas de habitat de los atunes y las agujas de abanico, o sea, entre 40 - 120 metros. Las menores capturas de atunes que se obtuvieron en la parte oriental de la región - a pesar de la presencia en general de condiciones oceanográficas favorables - están relacionadas, a nuestro parecer, con las particularidades biológicas de las poblaciones, sobre las cuales no disponemos de informaciones.

4 CONCLUSIONES

(a) Durante el invierno las concentraciones comerciales de atunes en el Mar Caribe están situadas en zonas locales de descenso de las aguas, cerca de los torbellinos ciclónicos claramente evidentes.

(b) Las condiciones más favorables para el desarrollo de los organismos marinos que sirven de alimento a los atunes, existen en las regiones sur del Mar Caribe, principalmente en su margen suroccidental. Causa de este fenómeno es la formación de las zonas productivas a lo largo del límite izquierdo de la Corriente del Caribe.

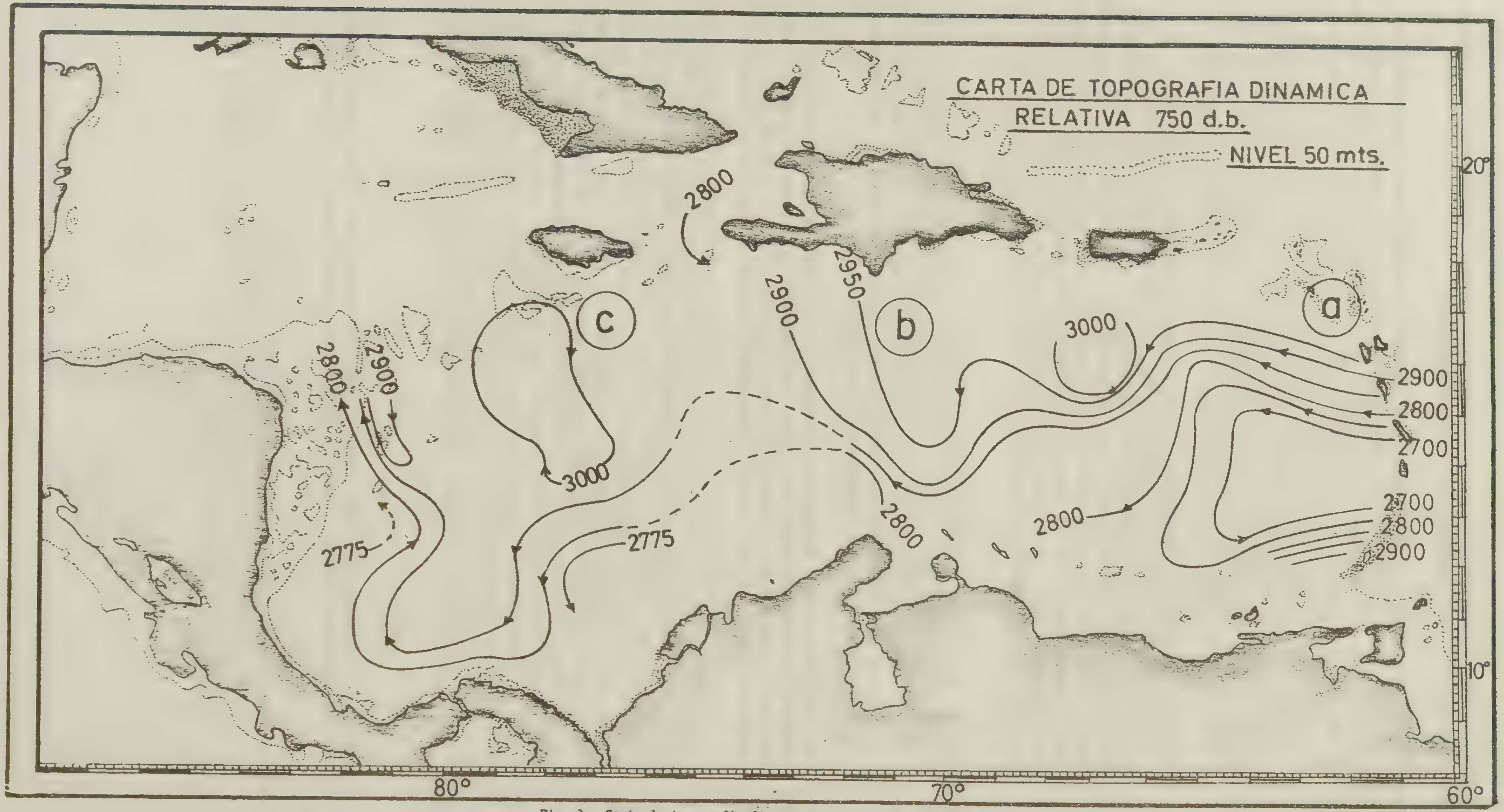
CARTA DE TOPOGRAFIA DINAMICA
RELATIVA 750 d.b.
NIVEL 50 mts.
a
b
c
2900
2800
2700
2700
2800
2900
3000
2950
2900
2800
2800
2800
2775
3000
2775
2900
2800
20°
10°
80°
70°
60°

Fig. 3 Carta de topografía dinamica relativa 750 d.b. (nivel 50 m)

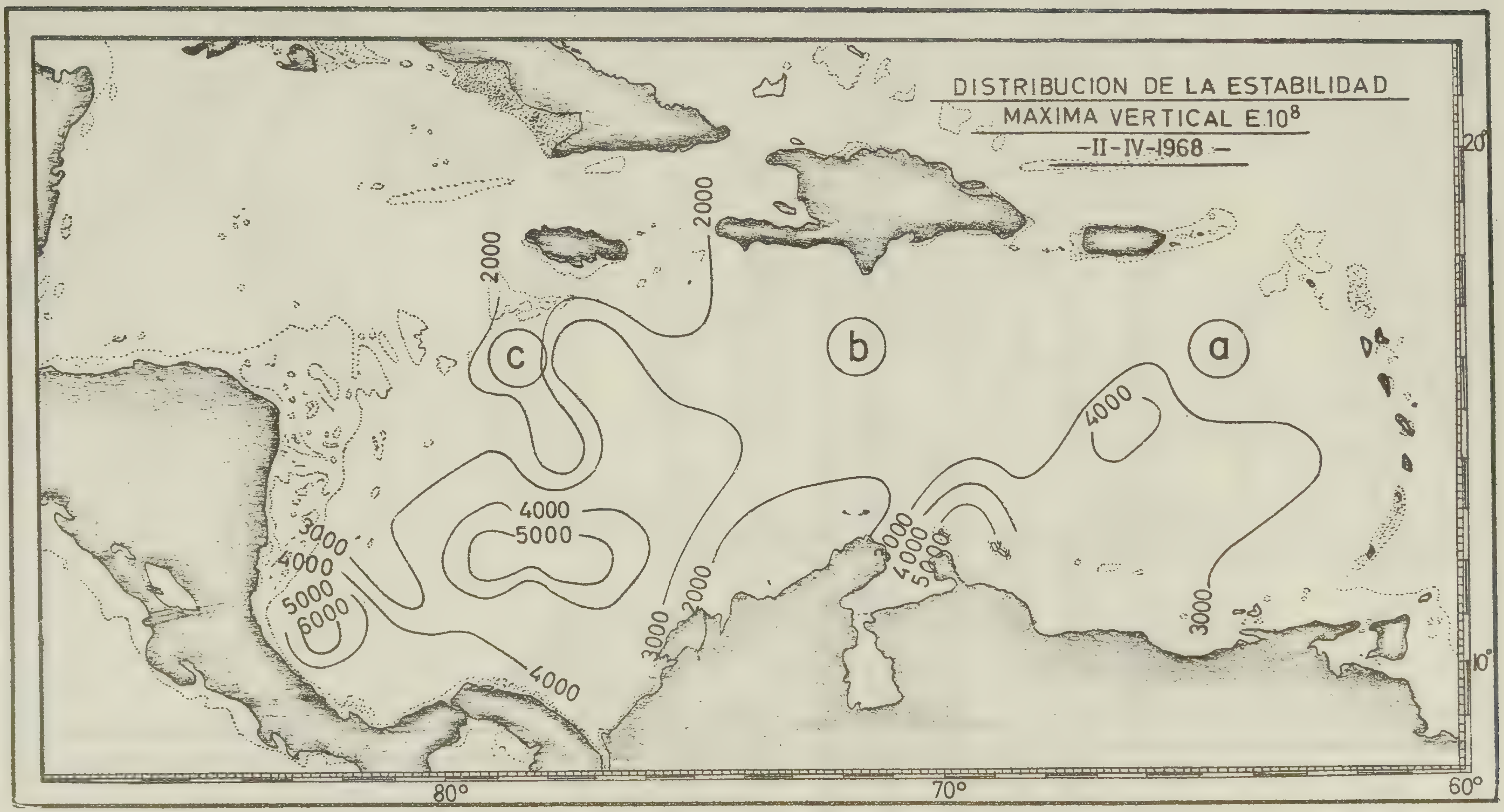
DISTRIBUCION DE LA ESTABILIDAD
MAXIMA VERTICAL E.10⁸
-II-IV-1968 -
a
b
c
2000
2000
3000
4000
5000
6000
4000
5000
3000
4000
5000
2000
3000
4000
3000
4000
20°
10°
80°
70°
60°

Fig. 4 Distribución de la estabilidad maxima vertical ($E.10^8$) para profundidades mayores de 2 000 m. Febrero-Abril

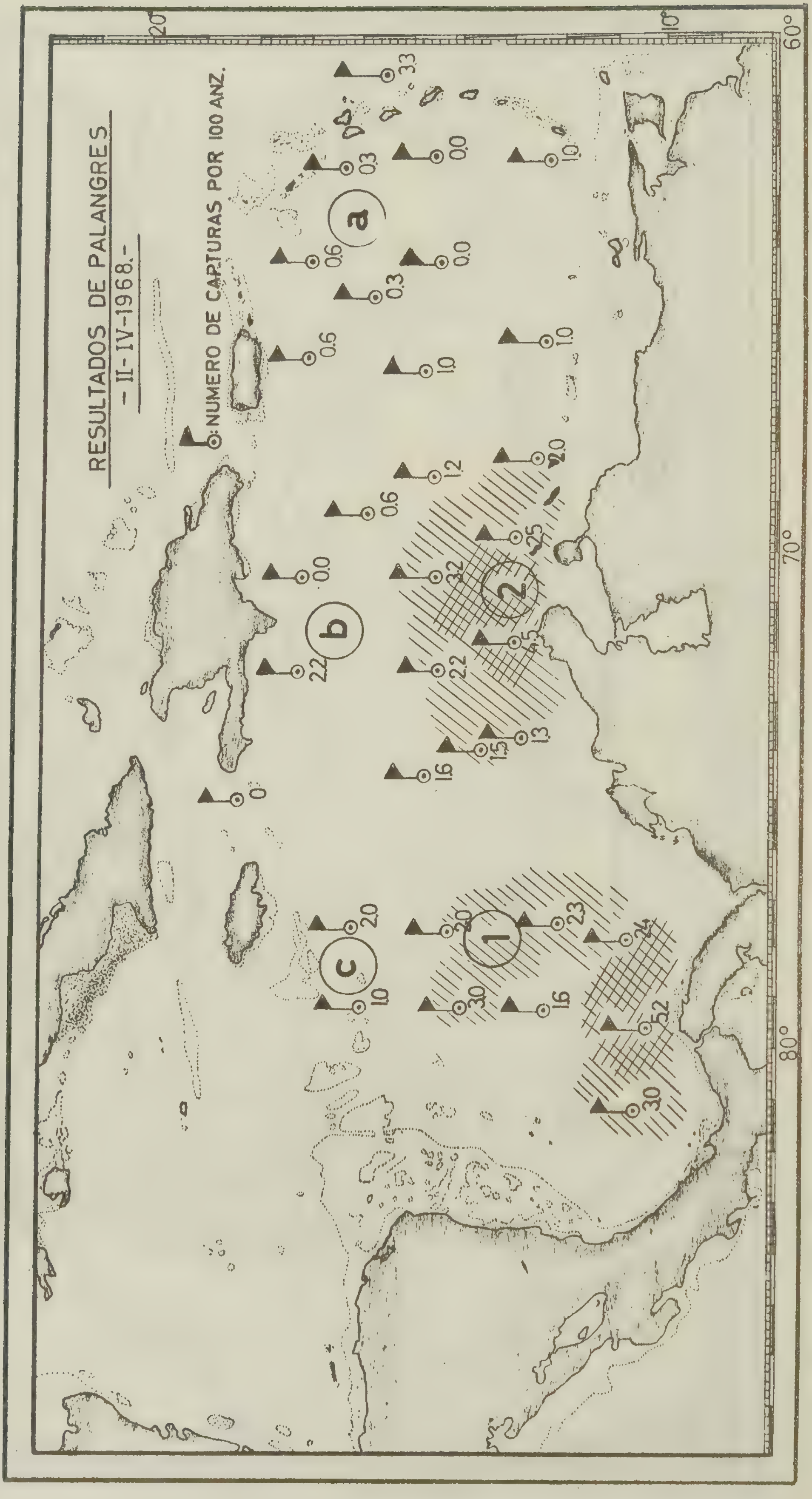
RESULTADOS DE PALANGRES
- II-IV-1968.-
NUMERO DE CAPTURAS POR 100 ANZ.
a
b
c
1
2
3.3
0.3
0.0
1.0
0.6
0.3
0.0
0.6
1.0
1.0
1.2
2.0
0.6
2.5
3.2
0.0
2.2
2.2
4.5
1.3
1.5
1.6
0.
2.0
2.0
2.3
2.4
1.0
3.0
1.6
5.2
3.0
20°
10°
60°
70°
80°

Fig. 5 Resultados de palangres. Febrero-Abril 1968

Los atunes habitan de preferencia las aguas con temperaturas de 22,0 a 25,0°C y salinidades de 36,5 a 37,0°/oo, lo que puede servir como referencia tanto para su búsqueda como para la elección de las profundidades óptimas de calada del palangre.

(c) La continuidad de los procesos hidrodinámicos (según datos de otros investigadores), permite asumir que, almenos en el período invernal, la situación de las principales zonas productivas en el Mar Caribe se mantiene invariable. Esto puede servir de base para intensificar la pesca atunera durante todo el año en el Mar Caribe.

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